HINTS ON
ELEMENTARY PHYSIOLOGY

FLORENCE HAIG-BROWN

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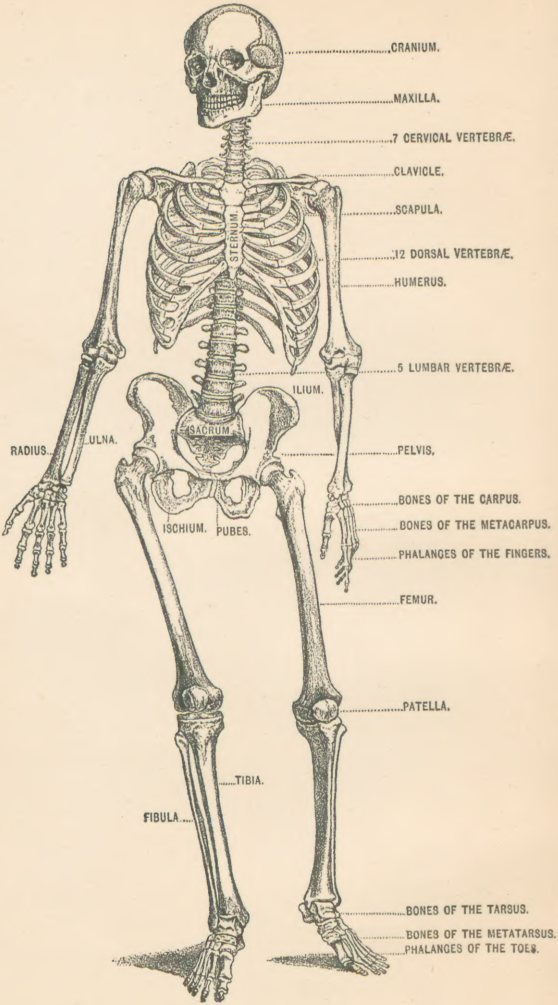
CRANIUM.
MAXILLA.
7 CERVICAL VERTEBRÆ.
CLAVICLE.
SCAPULA.
STERNUM.
12 DORSAL VERTEBRÆ.
HUMERUS.
5 LUMBAR VERTEBRÆ.
ILIUM.
SACRUM.
RADIUS.
ULNA.
PELVIS.
BONES OF THE CARPUS.
BONES OF THE METACARPUS.
ISCHIUM.
PUBES.
PHALANGES OF THE FINGERS.
FEMUR.
PATELLA.
TIBIA.
FIBULA.
BONES OF THE TARSUS.
BONES OF THE METATARSUS.
PHALANGES OF THE TOES.

HINTS

ON

ELEMENTARY PHYSIOLOGY

BY

FLORENCE A. HAIG-BROWN

WITH 21 *ILLUSTRATIONS*

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PREFACE

My friend and fellow-worker, Miss Florence A. Haig-Brown, has asked me to write a few words by way of preface to her "Hints on Elementary Physiology." I do so with a double good will, for the sake of the writer, and for the sake and memory of her sister, Miss Helen Haig-Brown, a very long-standing patient and dear friend, who after a successful career as Probationer and Sister at St. Thomas's Hospital was taken from us when entering on a wider sphere of usefulness. "The Hints" are, as is stated by Miss F. A. Haig-Brown, founded upon notes taken by the two sisters of the Lectures and Demonstrations given by the medical officers of St. Thomas's Hospital entrusted with the duty of giving such elementary instruction to the probationers as may help to fit them for the discharge of their duties in the wards. The sisters seem not only to have received instruction, but to have made, so to speak, a common fund, and what they have acquired and have found useful, the survivor has condensed for the help of her successors at

St. Thomas's and of her associates at the St. Marylebone Infirmary. The reception, the interchange, and the transmission of the lamps of knowledge are, as has long ago been recognised, an orderly and effective means for the promotion and for the application of Science. This book seems to me to embody to the full such a method. Its aspect is that of the learner. It registers the impressions received by attentive minds in the hours spent in the class-room. It is intended clearly to be helpful, but not final or complete, to be useful as a guide, available for reference, stimulating in much of its terseness and brevity to wider reading and study. As an evidence of earnest diligence in preparation for what is one of the most responsible, and certainly the very hardest possible, occupation in life, it calls for all praise and respect. The qualities of the book will, I am well assured, command the success which I most heartily wish for it.

WILLIAM M. ORD.

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CHAPTER I

PROTOPLASM

In order to understand the mechanism of our bodies, it is essential to know something of *Anatomy*, which, through dissection, teaches us how the various parts are formed and something of *Physiology*, which teaches us the functions of the various parts; and if we clearly understand the working of the body in natural health, we can then group more clearly the causes and reason of *Pathology* or *disease.*

If we compare any of the higher animals or men with the lowest known forms of living being, we cannot help being struck with the amazing structural complexity of the one and the extreme simplicity of the other.

The body of anything living, whether animal or vegetable, is built up of cells, which may be compared to bricks building up its structure. The

amœba is the lowest form of animal life, and is an apparently homogeneous lump of soft jelly; but it feels, it digests, it breathes, it discharges effete matter, it grows, it has the powers of locomotion and procreation; in fact, it fulfils all the primary and essential functions of life. Human beings, on the other hand, and all higher organisms, are supplied with special organs to fulfil these various functions:

(1) With nervous organs.
(2) With digestive organs.
(3) With respiratory organs.
(4) With excretory organs.
(5) With circulatory organs, &c.

A *cell* is composed of *Protoplasm* (living matter), an albuminous fluid, of which the chemical constituents are:

(1) Carbon. (3) Hydrogen.
(2) Oxygen. (4) Nitrogen.

With these are associated in various proportions:

(1) Sulphur. (5) Sodium.
(2) Chlorine. (6) Magnesium.
(3) Phosphorus. (7) Iron.
(4) Calcium.

Protoplasm ("the physical basis of life") exists in the human body as the white corpuscles of the blood, which have no wall and no nucleus. It is also found in all embryonic tissue, but by a process of development, or differentiation, the cells become nucleated. A nucleated cell has a wall of more

condensed protoplasm, and in the centre has a nucleus which appears to play an important part in reproduction. Cells are always formed from one another by multiplication; they are never *de novo* (spontaneously developed).

The second stage is aggregation of cells, as seen, for instance, in sponges.

The nucleus divides and a fresh cell is formed, and so on *ad infinitum.*

Powers of Cells.

A cell can take in nourishment.

A cell can secrete and excrete.

A cell can move.

A cell can multiply.

Therefore a cell is an *organism,* or matter which has life.

Cells vary in character in the different tissues, according to the functions they have to perform.

Some are round.	Some, stellated.
Some, long.	Some, ciliated.
Some, oval.	Some, flaky.

Cells are divided into different groups:

(1) Epithelial cells.

(2) Connective tissue cells.

(3) Tubular cells.

Each of these is subdivided into several varieties:

(1) *Epithelial tissue* cells are characterised by the circumstance that the cells which compose them are in contact layer upon layer. They vary a great

deal according to the situations they occupy and the functions they perform. The epidermis, or outer layer of skin, consists of epithelial tissue, and is entirely protective. It consists of several layers of cells, round at the bottom, becoming more flattened, and the upper layer becoming flakes.

In connection with the skin are numerous tiny, tubular glands, which are lined with delicate epithelial tissue; nails and hair are varieties of this tissue.

Such tissue also lines all cavities and all membranes:

(1) Synovial membrane.
(2) Mucous membrane.
(3) Serous membrane.

It also lines all ducts, blood-vessels, and lymphatics.

In the stomach and intestines the epithelial tissue *absorbs* as well as *protects*.

In the respiratory passages the cells are furnished with cilia, or small hairs.

In the glands of the liver, kidneys and skin the epithelial cells are globular.

(2) *Connective tissue* consists of nucleated masses of protoplasm which are often exceedingly minute, always surrounded by a wall of some thickness, and are either rounded or isolated from one another, or stellate, and furnished with processes communicating with those of the neighbouring cells.

The essential morphological distinction between

epithelial and connective tissue is, that in the former the cells are in absolute contact; in the latter they are separated from one another in a greater or less degree by some intervening substance of either inorganised deposit, or portion of the higher living tissues.

According to the nature and amount of this intervening substance, or to peculiarities presented by the cells, connective tissue may be divided into several varieties.

(a) *Common connective tissue*, as found in fasciæ and tendons; the protoplasm is scanty and stellate, and the intervals, which are large, are occupied by wavy bands of white fibrous tissue and more or less yellow elastic-fibre, both of which are either simple secretions from the living protoplasmic masses, or the mummies of defunct cells.

This variety of connective tissue yields gelatine.

(b) *Cartilage :* In common cartilage the cells are round or oval and separated from one another by a dense, homogeneous, elastic substance, which appears to be formed by the progressive thickening of the cell walls and by their coalescence.

This variety of connective tissue yields chondrine.

(c) *Bone :* In a transverse section of bone, when magnified, we see large round spaces called Haversian canals, which serve for the passage of blood-vessels, lymphatics and nerves from the exterior to the interior of the bone. Round the Haversian

canals are irregular, dark spaces, called "lacunæ"; connecting one lacuna with another are fine lines called "canaliculi" which also communicate with the Haversian canals. The intervals between the canaliculi are filled with bone earth; the lacunæ represent the living bone cells.

(d) *Fat*, sometimes called adipose tissue, in which the cells contain oil.

(e) *Mucous tissue*, as seen in the fœtus, in the tissue of the umbilical cord, also in the vitreous humour of the eye: in this form of connective tissue the intervals are filled with mucus which contains mucine.

(3) *Tubular tissue* is considered a higher development, and is formed by the juxtaposition and coalescence of cells, which have in some manner undergone a higher process of development. Under this head we have nerves, muscular fibre, capillary vessels and lymphatics, and complex organs such as muscles, bones, glands, brain, heart, liver, which are composed of *all* the various tissues.

For instance, the muscular fibres are *tubular*, united by fascia which is *connective tissue*, supplied with blood-vessels and lymphatics which are lined with *epithelial tissue*.

The different organs tend to arrange themselves into groups or systems such as:

(1) Circulatory organs.
(2) Secretory organs.
(3) Excretory organs

(4) Digestive organs.
(5) Organs of locomotion.
(6) Nervous organs, which govern and control all the others.

The motor cells have always one long fibre which enters into muscle and makes it contract, acting as a battery and supplying force.

In order that the cells should properly perform their function, the protoplasm of which they are composed must be healthy.

Unhealthy function is soon perceived and gives rise to what we call *symptoms*, meaning signs of disease.

It is by the multiplication of cells without the power to control their differentiation that we get cell diseases, namely, Tumours. A *Tumour* is a degenerating mass of cells. *Enchondroma*, a cartilaginous tumour. *Neuroma*, a nerve tumour, and when found in the fœtus this loss of power brings about malformation or fusion of parts.

CHAPTER II

THE FORMATION OF BONE

Bone is composed of two kinds of constituents:

(1) *Organic* or *animal matter.*

(2) *Inorganic* or *earthy matter.*

The animal material consists of *gelatine*, *albumen*, *fibrin*, and *blood-vessels.*

The earthy material consists of:

(1) *Phosphate of calcium.*

(2) *Carbonate of calcium.*

(3) *Fluoride of calcium.*

(4) *Phosphate of magnesia.*

(5) *Chloride of sodium.*

(6) *Oxide of sodium.*

In the adult there should be two parts of inorganic matter to one part of organic matter. In children there is a larger proportion of organic material, therefore their bones are soft and do not fracture so easily, but rather bend.

Thus in the disease of *Rickets*, to which young children are subject, the bone indeed grows, but the inorganic material is not formed and the bones

Fig. 1.—Section through ossifying cartilage and young bone. (Cadiat.)

a. Cartilage cells.
b. Degenerating cartilage cells.
c. Cell space, empty.
d. Spiculæ of calcareous deposit.
e. Blood corpuscles.
f. Osteoblasts.
g. Ditto of periosteum.
h. Bone cells.

remain soft and pliable. Such, too, is the case in *Mollities ossium*, when the bones contain too little organic material. In elderly people there is a larger proportion of inorganic material than in younger people ; hence their bones are very brittle ; they fracture easily and re-union is very difficult, as it is the organic material of bone which furnishes the plastic material for the union of the divided ends.

Bone is composed of two kinds of tissue, *Compact tissue*, the outer layer, which is dense in texture like ivory.

Cancellous tissue, the inner layer, which consists of slender fibres like lattice-work.

Every bone is covered by a fine membrane, called the *periosteum* and lined by a still finer membrane called the *endosteum*.

Bones are richly supplied with nerves and blood-vessels, and these are brought to the bone by means of the *periosteum*. On the surface of the bone there are *foramina* (openings) to be seen, into which the periosteum dips so as to allow the passage of the nerves and blood-vessels to the interior of the bone.

The periosteum consists of two layers: the outer formed chiefly of connective tissue, containing a few fat cells ; the inner of elastic fibres and blood-vessels.

Uses of Bone.

(1) Bones determine the general shape and proportion of the body.

(2) Bones give attachment to the muscles and form levers, by means of which the muscles act to move the body from one position to another. Bones are considered as both active and passive agents of locomotion.

(3) Bones form cavities for the protection of important organs; they must therefore be strong, elastic, and light.

Bones may be classified as:

(1) *Long Bones*, found in the extremities and serving for locomotion.

(2) *Flat Bones*, as in the head and sternum, serving for protection.

(3) *Short Bones*, such as the bones of wrist or ankle, where strength and limited action are required.

(4) *Irregular Bones*, as the vertebræ, which cannot be classed under any of the preceding heads. Long bones have a cylindrical hollow in the centre which contains the *medulla* or *marrow*. Long bones contain yellow marrow, whilst short and flat bones contain red marrow.

Cancellous tissue also contains a red marrow which is an organ of physiological importance. Bone grows in *width* by means of *periosteum*. There is no periosteum at the end of bone. Bone grows

in *length* by means of *cartilage*, and the point of the cartilage at which the bone grows is called the *epiphysis* (growing on). There are about two hundred bones in the human skeleton; but more than two hundred would be found in a child's body, less than two hundred in an adult's, for the bones coalesce with advancing age.

Bone enters largely into the formation of joints.

A *Joint* is composed of :

(1) Bone.
(2) Cartilage.
(3) Synovial membrane.
(4) Ligaments.
(5) Muscles around joint.

(1) *Bone* is the principal element in joints; in long bones the extremities forming the articulation are generally enlarged and formed of cancellous tissue, covered by a thin layer of compact tissue. This outer tissue, called *Articular Lamella*, differs from ordinary bone in having larger lacunæ, no Haversian canals and no canaliculi.

(2) *Cartilage* appears to the naked eye very much like the white inside of a cocoanut, or the hard-boiled white of an egg; under the microscope it is almost formless, but in certain parts there are cells enclosed in capsules; its use is to act as a buffer and to break the shock of movements. It has no nerves and consequently no sensation, and is devoid of blood-vessels. It receives its nourishment from the synovial membrane and below from

the bone itself. (Cartilage and synovial membrane are the parts most commonly diseased in a joint.) In caries, or ulceration of bone, not only do the cartilage and synovial membrane disappear but the bone itself decays. If the synovial membrane be injured, the cells secrete not only synovia but serum. This causes swelling, or "water in a joint."

(3) *Synovial Membrane* is a very thin layer of connective tissue, finer than the finest tissue paper. It is abundantly supplied with blood-vessels. On its surface is a layer of cells which separate the synovia from the blood-vessels and pour it on to the cartilage, so acting like joint-oil and keeping the cartilage smooth; in connection with the synovial membrane are hollow fringes which are very active in secreting the synovial fluid.

(4) *Ligaments* are found in connection with all joints; they consist of bundles of white fibrous tissue, closely interlaced with each other, presenting a shiny, silvery appearance; they are pliant and flexible, but strong and tough, and help to bind and keep in place the bones which form the joint.

(5) *Muscles*, with their extremities or tendons are also agents in keeping the joint surfaces in their place.

There are six kinds of joint movement:

(1) Abduction.
(2) Adduction.

(3) Circumduction.
(4) Extension.
(5) Flexion.
(6) Rotation.

Joints may be divided into two classes :

(1) *Movable*, comprising—

(*a*) Ball-and-socket joint (as in the hip).
(*b*) Hinge joint (as in the knee).
(*c*) Gliding joint (as in wrist and ankle).

(2) *Immovable*, where the bones are in direct contact, as in the head and face.

CHAPTER III

THE BONES OF THE SKELETON

THE **Skeleton** may be divided into three parts :

(1) The Head (cranium and face).
(2) The Trunk (thorax and abdomen).
(3) The Extremities (upper and lower).

The *Bones* of the *Head* are eight in number :

(1) Frontal (front bone).
(2) Parietal (two side bones).
(3) Occipital (back bone).
(4) Temporal (two temple bones).
(5) Sphenoid (wedge bone).
(6) Ethmoid (sieve bone).

The bones of the head are flat and tabular, and are intimately connected with each other by means of natural sutures (stitches).

The flat bones of the head consist of three layers :

(1) The outer table.
(2) Diploë.
(3) The inner table.

The *outer table* consists of dense compact tissue.

The *diploë* consists of cancellous tissue, and acts as a buffer.

The *inner table* is extremely brittle, like glass, hence it is called the *vitreous.*

The *frontal bone* has a fancied resemblance to a clam shell; it consists of two plates—the *vertical,* which forms the forehead, and the *horizontal,* which forms part of the roof of the orbit. In the centre of the horizontal or orbital plate is the *nasal spine,* to which the bones of the nose articulate; below the spine is the *nasal notch;* on either side of the nasal spine is the *supra-orbital arch,* and above the arch again is the *supra-ciliary* ridge, which forms the eyebrows.

The *nasal notch* is for the articulation of the ethmoid bone.

The *supra-ciliary* ridges are hollow and connected by cavities with the nose.

On the outer side of the supra-orbital arch is the *external angular process,* for the articulation of the malar or cheek bones.

Behind the external angular process is a depression for the *lachrymal gland.*

Sometimes in the middle line of the vertical plate of the bone are seen some sutures, indicating the original separation of the two halves of the bone.

The frontal bone articulates behind with the two parietal bones; in front with the two malar bones; also with the two nasal bones; and with the sphenoid and ethmoid bones.

The *Parietal bones.*—The name is derived from a Latin word meaning side-wall. They are situated on each side of the *vault*, the two forming together a beautiful arch for the protection of the brain; each is four-cornered, hollowed out from above downward, and from front to back.

They have an outer and inner surface and four borders. The outer surface is smooth and dense; the inner surface is less smooth and marked by depressions for the convolutions of the brain and by numerous grooves for the middle meningeal artery. Three of the borders are serrated or toothed, the upper borders articulating with each other; the anterior articulating with the frontal bone, and the posterior with the occipital bone; the lower border is thin and bevelled at the expense of the outer table and articulates with the temporal bone; at the posterior inferior angle is another sinus for the middle meningeal artery.

The *Occipital bone.*—This occupies the back and base of the skull; it rests upon the upper end of the spinal column; it forms one bone with the sphenoid in the adult, and is usually separated by sawing through the *basilar process* which unites them.

In shape it is very irregular, four-sided, perforated near its anterior angle by a large oval hole, called the *Foramen Magnum;* it has two surfaces, four borders and four angles, the exterior surface is for the most part tough; in the middle line is a tubercle called the *external occipital protuberance;*

on either side of the foramen magnum are oval, convex bodies called *condyles*, which rest in depressions on the first of the vertebræ; in front of each condyle is a smaller foramen for the passage of nerves; behind each condyle is another foramen for a vein passing into the lateral sinus; the *basillar process* of the bone is its continuation forward into the sphenoid, the inner surface is smooth; two ridges run across it, and where they cross they form the internal occipital protuberance.

The *occipital bone* articulates in front with the two parietal and the two temporal bones, and at the base with the sphenoid and atlas. The *sphenoid*, or *wedge bone*, fits in at the base of the skull, in front of the occipital bone and behind the frontal and facial bones; it somewhat resembles a bat with wings spread and legs hanging down.

The centre part is called the body, and on either side stretch the *alæ majores;* in front of the body are the *alæ minores;* springing from the centre of the body and hanging down are the *pterygoid processes;* in front of the body is a projection called the *ethmoidal spine*, which fits it into the back of the ethmoid. At the roots of the lesser wings are small foramina for the passage of the optic nerve. On the upper part of the body is a depression called the *sella turcica*, or Turk's saddle. The sphenoid bone sends out processes to touch all the other bones of the cranium, and also some of the bones in the face.

The *Temporal bone* is usually divided into three portions; a thin vertical division, called the *squamous portion*, at the lower end of which is a process running forward named the *zygoma;* below and behind the squamous portion is a nipple-like process called the *mastoid;* at the inner surface and running towards the base of the brain is the *petrous portion.*

Between the mastoid and zygoma is the externa auditory foramen; exactly behind the zygoma is a deep groove called the *glenoid cavity*, for the articulation of the condyle of the lower jaw; behind the mastoid process is a groove, the *jugular fossa;* in the petrous portion is the inner auditory foramen.

The *Ethmoid*, or *sieve bone*, occupies the cleft in the frontal bone between the two orbits, and forms the upper part of the nasal cavity; it consists of a horizontal plate which occupies the base of the skull; a vertical plate which forms the upper part of the *septum* of the nose and two lateral masses consisting of cells or cavities; on its upper surface is a perforated plate called the *cribriform plate*, and a projection resembling a cock's comb, named the *crista galli.*

There are three fossæ in the base of the skull in which the brain rests:

(1) The posterior fossa (the deepest).
(2) The middle fossa (less deep).
(3) The anterior fossa (the most shallow).

Bones of the Face.

The bones of the *face* are *fourteen* in number:

(1) 2 Superior maxillæ.
(2) 1 Inferior maxilla.
(3) 2 Nasal bones.
(4) 2 Malar bones.
(5) 2 Lachrymal bones.
(6) 2 Palate bones.
(7) 1 Vomer.
(8) 2 Turbinated bones.

The *Superior maxillæ* form the greater part of the face between the orbit and the mouth. Each consists of a hollow body called the *antrum* or cave, a vertical plate which runs inwards and upwards, the inner and upper part forming the malar processes, the lower border and the vertical plate forming the *alveolar processes*, with sockets for the roots of the teeth. Running inwards and backwards from the alveolar process is the *palatine process* forming two-thirds of the hard palate. The roof of the antrum forms part of the socket of the eye; at the inner and lower border of the orbital plate is a groove for the nasal duct, which communicates with the nostril.

The superior maxillæ articulate with the frontal bone, with the two nasal bones, with the two lachrymal bones, with the two malar bones, with the two turbinated bones, with the vomer, and with the ethmoid bone.

The *Inferior maxilla* constitutes the lower jaw; it is developed in two halves, which in process of time unite, this union is called the *symphysis* of the lower jaw; it presents the appearance of a horse-shoe, consisting of a body, two horizontal rami, and two vertical rami; the lower border of the body is called the chin; it is peculiarly strong; the upper border contains the alveolar process for the teeth of the lower jaw; the union of the horizontal and vertical rami is called the *angle* of the jaw.

The *nasal bones* form the bridge of the nose; they are oblong in shape and articulate with each other and with the superior maxillæ; the upper border with the frontal bone, whilst the lower border is thin and jagged for the attachment of cartilage.

The *malar bones* form the prominence of the cheek; they enter into the formation of the orbit, also into the formation of the temporal and zygomatic fossæ. They are four-sided, and have four angles; the superior exterior angle articulates with the frontal bone; the inferior exterior angle articulates with the zygoma, forming the zygomatic arch; the anterior and also the posterior inferior angles articulate with the superior maxilla. The outer surface is very strong, forming a prominence which acts as a safeguard to the eye.

The *Lachrymal bones* are situated at the inner and lower border of the eye; they are the most delicate bones in the body—they present a

grooved appearance for the support of the nasal duct.

The *palate bones* are situated at the back of the nasal fossa, between the superior maxillæ and the pterygoid processes. They serve to lengthen backward the hard palate, and serve also for the attachment of the various muscles of the pharynx.

The *vomer*, or *plough-share*, is placed in the median line below the body of the sphenoid, and forms the back part of the septum of the nose.

The *turbinated* are spongy bones, curved and twisted upon themselves, and are found in either nostril. They serve to give greater surface to the mucous membrane, which is very vascular, and transmits the *olfactory nerves*. They, with the lateral masses of the ethmoid, form the three divisions of the nose:

(1) Upper meatus.
(2) Middle meatus.
(3) Lower meatus.

CHAPTER IV

THE BONES OF THE SKELETON—(*continued*)

The bones belonging to the *vertebral column* are twenty-four in number.

The *vertebral column* is the pivot on which the body turns; it is an organ of support and also an organ of protection—it is shaped like a pyramid, forming three curves.

2 Convex curves.
1 Concave curve.

The *vertebræ* are divided into:

7 Cervical (neck).
12 Dorsal (back).
5 Lumbar (loin).

Between each vertebra there are inter-vertebral discs which act as buffers; these buffers are formed of yellow elastic tissue and fibrous tissue. Each *vertebra* consists of a body, from which springs an irregular arch, which arch forms the spinal foramen for the spinal cord; on either side at the commencement of the arch spring seven processes, two above the pedicles, which jut out

from the side and are called transverse or lateral processes; nearer together and between the lateral processes are the lower articular processes; in front of them and still nearer together are the two upper articular processes; between the two lower and the two upper are two plates of bone, called *laminæ*, which form the roof of the arch; they are pinched up together and form the *spinous process.*

Each *vertebra* therefore consists of:

(a) 1 Body.
(b) 2 Pedicles.
(c) 2 Transverse processes.
(d) 2 Upper articular processes.
(e) 2 Lower articular processes.
(f) 1 Spinous process.
(g) 2 Laminæ.
(h) 1 Vertebral foramen.

The five lumbar vertebræ are the largest, their bodies are broad and thick, pedicles strong, laminæ short, spinous process horizontal.

The twelve dorsal vertebræ are smaller than the lumbar; their bodies are somewhat triangular; pedicles nearly on a level with the upper margin of the body; their laminæ are broad and thick, their spinous processes long and oblique; their transverse processes clubbed, having *facets* on them for the articulation of the ribs; their spinal foramina are round.

The cervical vertebræ are the smallest; their transverse processes are perforated for the passage

of the vertebral arteries; their spinous processes are short and bifurcated; their bodies very small. The first cervical vertebra, called the *atlas*, is fixed to the head by means of ligaments; it has not any body, but has two side masses connected in front and behind by an arch forming an almost complete ring.

The second cervical vertebra is likewise very peculiar; it is called the *axis;* it has a body from the upper surface of which projects a tooth-like body, *the odontoid process*, which serves as an axis for the atlas to revolve upon; its transverse processes are short and perforated; its spinous process bifurcated and channelled below.

The seventh cervical vertebra is remarkable for its long spinous process and is therefore called *vertebra prominens.*

The Pelvis.

A brim divides the pelvis into two parts, the true and false pelvis: the false above, the true below. The pelvis directs the weight of the body on to the lower extremities, it consists of:

(1) The sacrum. (2) Two innominate bones.

The *sacrum* is the direct continuation of the vertebral column, being in fact the fusion of five or six bones, which in the fœtus are separate. It is placed between the last lumbar vertebra above and the coccyx below, with an innominate bone on either side. It is a triangular, wedge-shaped

bone, with base above, and apex below; the inner surface is smooth and concave, whilst the upper edge projects forwards and is called the "promontory," it presents indications by means of transverse lines of the original division of the bone. At the extremities of the lines are foramina, continuous with those of the vertebral column, for the transmission of the nerve trunks. The posterior or dorsal surface is convex, presents down the middle line spinous processes, and on either side laminæ which form the continuation of the spinal foramen. The lateral masses on either side consist of coalesced transverse processes.

The upper and outer angles present peculiarly roughened surfaces, alternately convex and concave for articulation with the innominate bone, the *sacro-iliac synchondrosis.* At the apex of the sacrum is the *coccyx*, consisting of four or five rudimentary vertebræ; the first piece is broad and articulates with the sacrum, the second articulates with the first, the third and fourth are mere nodules, coalescing with the second.

In middle life the first piece is usually separated while the rest are fused together.

In advanced life they are all united together and with the sacrum, sooner in males than in females.

The *innominate bone* is an irregularly shaped bone forming part of the pelvis; in the child it is developed in three parts.

(1) The ilium.
(2) The ischium.
(3) The pubic bone or pubes.

These three bones form a cup-like cavity called the *acetabulum*.

The *ilium* is the flattened portion which supports the flank.

The *ischium* is the strong portion which supports the buttocks and on which we rest when sitting.

The *pubes* is the front portion and supports the organs of generation.

Between the ischium and the pubes is a large hole, named *obturator* or *foramen ovale*.

The upper border of the ilium is called its *crest;* the crest ends in front in a thick angle, the *anterior superior spine*, to which is attached a ligamentous structure, called *Poupart's ligament*, which runs to the angle of the pubes.

Below the notch is the anterior inferior spine; tracing the crest backwards is the posterior superior spine, then an excavation, the *ischiatic notch*.

The lower portion of the ilium enters into the formation of the acetabulum with the ischium and pubic bone.

The *ischium* consists of a body which also enters into the formation of the acetabulum. Forwards and downwards is its tuberosity on which we rest when sitting; curving upwards and forward is its

ascending ramus which articulates with the pubic bone and helps to form the foramen ovale.

The *pubic bone* has a body and two branches ; the upper branch assists in the formation of the acetabulum, the lower branch articulates with the ischium.

The two pubic bones unite in front by means of a fibro-cartilaginous disc to form the *symphysis pubis.*

The Bones of the Extremities.

The *femur*, or *thigh-bone*, is the longest, largest, and strongest bone in the skeleton.

The *femur*, as all other long bones, consists of a shaft and two extremities—the upper extremity presenting a head, neck, and the greater and lesser *trochanters ;* the head is globular and forms rather more than a hemisphere ; its surface is smooth and coated with cartilage. The neck is a flattened pyramidal process of bone, which connects the head with the shaft; it varies in length and obliquity at various periods of life and under different circumstances.

The *trochanters* are prominent processes of bone which afford leverage to the muscles which rotate the thigh on its axis.

The *great trochanter* is a large, quadrilateral, irregular eminence situated at the outer side of the neck, at its juncture with the upper part of the shaft ; it has two surfaces and four borders.

The *lesser trochanter* is a conical eminence; its summit is rough, and gives insertion to the *psoas* muscle. The shaft is almost perfectly cylindrical in form; it is a little broader above than in the centre and is highly arched.

The lower extremity is larger than the upper, is of a cuboid form, and divided into two large eminences called the *condyles* (knuckles) with a notch between, called the *intercondyloid notch*.

The skeleton of the leg consists of three bones:

(1) Patella. (2) Tibia. (3) Fibula.

The *patella*, or *knee-cap*, is a flat, triangular bone, situated at the anterior part of the knee joint; it is composed mainly of dense cancellous tissue, and protects the front of the joint. It has two *facets* (small plane surfaces) for the articulation of the condyles of the femur.

The *tibia*, or *shin bone*, is situated at the front and inner side of the leg, and in length and size is only second to the femur; it also consists of a shaft and two extremities. The upper extremity, or head, is large and expanded on each side into two lateral eminences, the *tuberosities*, which present two smooth, concave surfaces which articulate with the condyles of the femur.

The lower extremity is much smaller than the upper and presents five surfaces. It forms the inner ankle.

The *fibula*, or *splint bone*, is situated at the outer side of the leg, and is, in proportion to its length,

the most slender of the long bones; it has a shaft and two extremities.

The upper extremity is small and placed below the level of the knee-joint, and is excluded from its formation; the lower extremity inclines a little forward and forms the outer ankle.

The *foot* consists of three divisions:

(1) Tarsus. (2) Metatarsus. (3) Phalanges.

The bones of the *tarsus* are seven in number.

(1) Calcaneum. (5) Internal cuneiform.
(2) Astragalus. (6) Middle cuneiform.
(3) Cuboid. (7) External cuneiform.
(4) Scaphoid.

The *metatarsal bones* are five in number; they are long bones, and each has a shaft and two extremities. The *phalanges of the foot* resemble those of the hand, both in number and general arrangement; there are two in the great toe and three in each of the other toes.

Bones of the Upper Extremity.

The *humerus* is the longest and largest bone of the upper extremity. It has a shaft and two extremities; the upper extremity is the largest part of the bone; it has a rounded head, and is joined to the shaft by a constricted portion called the neck and two other eminences, the greater and lesser tuberosities.

The lower extremity is flattened and curved slightly forwards, and has a general surface which,

with the bones of the forearm, forms the elbow-joint.

The *radius* is the outer bone of the forearm; it is a long bone which articulates with the humerus; it is largest at the lower end where it comes in contact with the first row of carpal bones.

The *ulna* is a long, irregularly shaped bone, articulating above with the humerus and below with the radius; at its upper end is a projection which forms the joint of the elbow; it is called the *olecranon*, and gives attachment to the muscles coming from above. The space between the radius and the ulna is called the *interosseus space.*

The *carpus* consists of eight small bones of irregular shape, so bound together by ligaments as to allow of gliding movements between them; they articulate with the radius and ulna above, with each other, and with the metacarpal bones below; the carpus as a whole is arched, and may be divided into two rows, four bones in each.

First row.	(1)	Scaphoid (boat-like).
	(2)	Semilunar (half-moon).
	(3)	Cuneiform (wedge-shaped).
	(4)	Pisiform (pea-shaped).
Second row.	(1)	Trapezium (square).
	(2)	Trapezoid (table-shaped).
	(3)	Os magnum.
	(4)	Unciform (hook-shaped).

The bones of the wrist are numerous, in order to give greater mobility to the part.

The *metacarpal bones* are placed between the wrist and the fingers, and are composed of five bones. That belonging to the thumb is called the first, and that of the little finger is called the fifth. They articulate above with the carpus and below with the first bone of the thumb and the fingers, the whole together form the palm of the hand and ball of the thumb.

The *phalanges* consist of three small bones forming each finger; the thumb has only two.

The *clavicle*, or *collar-bone*, takes its name from a fancied resemblance to an ancient key (*clavis*); one is placed on each side of the upper part of the chest; its inner end is articulated to the sternum, and its outer end to the scapula; its use is to support the shoulder.

The *scapula*, or *shoulder-blade*, is a flat bone of a triangular shape, placed at the back of the shoulder; on its outer surface runs a ridge which divides it into two unequal parts. The scapula is attached to the spinal column and ribs by strong muscles, and it articulates at its upper and outer edge with the clavicle and with the humerus.

The *thorax*, or *chest*, is formed by the sternum in front, twelve ribs on either side, and twelve dorsal vertebræ behind.

The *sternum*, or *breast-bone*, occupies the front of the chest, and supports the inner ends of the clavicle; seven of the costal cartilages are connected with

the sternum on each side. The sternum has been likened to a sword, the upper part being called the *manubrium*, or *handle*, the middle part the *gladiolus*, or *blade*, whilst appended to the latter is a small point of fibro-cartilage, called the *ensiform*.

The *ribs*, or *costæ*, form the greater part of the wall of the thorax; they are twenty-four in number, twelve on each side, and articulate behind with the twelve dorsal vertebræ.

The upper seven are called *true ribs;* they are attached in front to the sternum by costal cartilages.

The next three (eighth, ninth, and tenth) are connected with the costal cartilages of those above.

The last two are free, and are called *floating ribs*, each being tipped with costal cartilage.

The true ribs are more easily broken than the false, because the false are more yielding.

CHAPTER V

THE CIRCULATORY ORGANS

THE organs of the circulation are the

(1) Heart.	(4) Capillaries.
(2) Arteries.	(5) Lymphatics.
(3) Veins.	(6) Various ductless glands.

The *heart* is a hollow muscular organ, about the size of the closed fist of the person to whom it belongs. It varies much in size. The weight in a male is about 10 to 12 ounces, in a female about 8 to 10 ounces.

The heart is situated in the *mediastinum*, or centre of the thorax, in an upper direction from right to left.

It is invested by a double serous membrane called the *pericardium*.

The upper part of the heart is broad and called the *base*, whilst the lower end, round and pointed, is called the *apex*.

The upper surface of the heart is somewhat convex, whilst the under surface is flattened and rests upon the diaphragm.

The heart is held in place by the large vessels which spring from it.

The heart is divided internally from the base to the apex by a muscular wall, or *septum*, into the right and left sides. Each side of the heart is sub-divided into two chambers, the upper called *auricles*, and the lower called *ventricles*.

The openings between the auricles and ventricles are called *auriculo-ventricular* openings and they are guarded by means of valves.

The valves on the right side of the heart are called *tricuspid*, because they are divided into three folds or cusps.

Those on the left side are called *bicuspid*, or *mitral*, valves, from a fancied resemblance to a bishop's mitre.

The walls of the heart are muscular and vary in thickness according to the amount of work they have to do.

The walls of the auricles therefore are comparatively thin, as they simply receive blood and pass it on to the ventricles, whereas those of the right ventricle are thicker, because they force the blood into the pulmonary artery and the lungs, whilst those of the left ventricle are thickest of all, because they have to force blood through the aorta all over the body. Each cavity of the heart is supposed to be capable of containing about ℥ij of blood.

The heart substance is composed of layers of

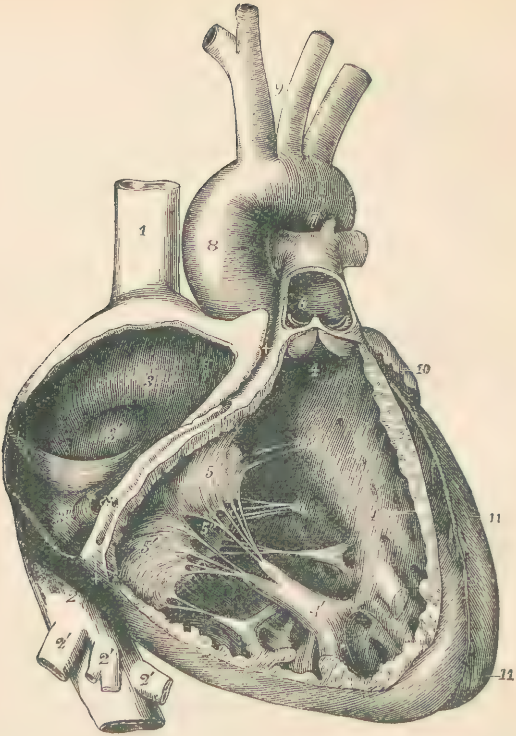

Fig. 2.—Interior of Right Auricle and Ventricle exposed by the removal of a part of their walls. (Allen Thomson.)

1. Superior vena cava.
2. Inferior vena cava.
2'. Hepatic veins.
3, 3', 3''. Inner wall of right auricle.
4, 4. Cavity of right ventricle.
4'. Papillary muscle.
5, 5', 5''. Flaps of tricuspid valve.
6. Pulmonary artery, in the wall of which a window has been cut.
7. On aorta near the ductus arteriosus.
8, 9. Aorta and its branches.
10, 11. Left auricle and ventricle.

muscular fibres: an inner layer of oblique fibres, a middle layer of circular fibres, and an outer layer of longitudinal fibres, which all contract evenly together.

Fat fills up the spaces between the muscles like a cushion.

Rising from the walls of the ventricles internally there are small muscular pillars called *papillary muscles*, which terminate in fine thread-like tendons called *chordæ tendineæ*, and the extremities of these are attached to the edges of the valves; therefore when the papillary muscles contract they pull on the chordæ tendineæ and these help to open the valves and allow of the passage of the blood from auricle to ventricle.

Arteries always carry blood *from* the heart, and as a rule convey pure, bright-red (arterial) blood.

Veins always carry blood *to* the heart, and as a rule contain impure dark (venous) blood.

Arteries and veins are furnished with three linings or coats:

(1) An *inner* coat of *epithelial* tissue.

(2) A *middle* coat of *muscular fibres* (very weak in veins).

(3) An *outer* sheath of *connective* tissue.

Veins, especially those of the lower extremity, are also provided with valves which assist in returning venous blood to the heart.

Capillaries (capillus = a hair) form a network of thread-like vessels and intervene between the

smallest arteries and the radicles or commencements of veins; they have exceedingly thin walls, through which their contents ooze out to nourish the tissues.

Lymphatics are very fine vessels which originate in the tissues, they lie with open mouths and absorb lymph or any superabundant nourishment from the blood; at intervals they run into glands in which their contents undergo certain changes, and which help to form the corpuscles of the blood.

The *spleen* is a ductless gland situated on the left side of the body under the diaphragm, and its function is supposed to be the manufacture of the white corpuscles of the blood.

All venous blood is collected by means of small veins which run into larger vessels and finally empty themselves into one of the two large trunk veins; those *below* the heart empty themselves into the *inferior vena cava*, those above the level of the heart empty themselves into the *superior vena cava.*

The Circulation.

Impure venous blood is brought through two openings to the right auricle by means of the superior and inferior venæ cavæ. The auricle dilates to receive it, then contracts on its contents; at the same time the papillary muscles in the ventricle contract, and by means of the chordæ tendineæ open the tricuspid valve and allow of the

passage of the blood from the right auricle to the right ventricle—the ventricle dilates to receive the blood, then contracts on its contents, closes the tricuspid valve to prevent regurgitation, opens the semilunar valves, and drives the blood into the pulmonary artery by which it is carried to the lungs. The pulmonary artery divides into the right and left pulmonary arteries, which subdivide into smaller and smaller branches, finally terminating on the walls of the air-cells, where the blood comes into contact with oxygen and is purified of its carbonic acid; the purified blood is taken up by other capillaries which run into veins and finally empty themselves into the left auricle; the left auricle dilates to receive the blood, then contracts, the mitral valve opens and allows of the passage of the blood into the left ventricle; the left ventricle dilates to receive the blood, then contracts, shutting the mitral valves and opening the semilunar valves into the aorta, into which it propels the blood, and by which vessel and its branches the blood is carried to all parts of the body.

The sides of the heart are symmetrical and act synchronously (at the same time). Auricles dilate and contract simultaneously. Ventricles dilate and contract simultaneously. Corresponding valves are open at the same time. The movement by contraction is called the *systole*. The period between two successive contractions is called the *diastole*.

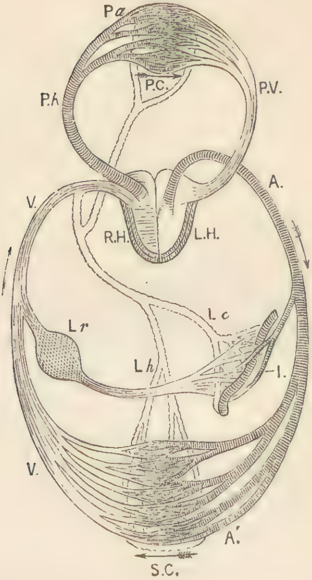

Fig. 3.—Diagram of the Circulation of the Blood and the Absorbent Vessels. (Yeo's "Physiology.")

- P*a*. Small pulmonary arterioles.
- P.A. Pulmonary arteries.
- P.V. Pulmonary veins.
- P.C. Pulmonary capillaries.
- V. Wide systemic veins.
- A. Larger systemic arteries.
- R.H. Right systemic heart.
- L.H. Left systemic heart.
- Lr. Liver.
- L*h*. Lymphatics.
- Lc. Lacteals.
- I. Intestines.
- A′. Smaller systemic arterioles.
- S.C. Systemic capillaries.

Course of the Aorta and its principal branches.

At its very commencement the *aorta* gives off two branches, the *coronary arteries*, which turn back over the surface of the heart to nourish that organ itself; the aorta then takes an upward direction and arches over the root of the left lung; this arch is divided into three parts:

(1) The ascending aorta.
(2) The transverse aorta.
(3) The descending aorta.

From the transverse arch of the aorta three branches are given off:

(1) The innominate artery.
(2) The left carotid artery.
(3) The left subclavian artery.

The innominate artery is very short and soon bifurcates, forming the right subclavian and the common carotid.

The common carotid runs up the side of the neck, and when on a level with the thyroid cartilage bifurcates and forms the external and internal carotid arteries; the external carotid runs up the side of the face in front of the ear, giving off branches to the anterior portion of the face and also branches to the scalp.

The internal carotid enters the skull by the temporal bone, supplies blood to the brain and its membranes, forming with other arteries the circle of Willis. The right subclavian passes under the

clavicle, takes a downward course to the axilla, where it is called the axillary artery, then passes downwards and forwards to the bend of the elbow, and is here called the brachial artery; about an inch and a half below the elbow it bifurcates, forming the radial and ulnar arteries. The radial artery takes its course along the outer side of the arm to the root of the thumb; here it dips deeply down and forms the deep palmar arch, giving off branches to the dorsal part of the hand and to the fingers.

(At the wrist the radial artery is very superficial, and is called the pulse, which is the beat of an artery synchronous with the contraction of the ventricles.)

The ulnar artery takes its course along the inner side of the arm, passes beneath the annular ligament and forms the superficial palmar arch, which gives off branches to the palm of the hand and front part of the fingers.

A portion of the descending aorta takes its course downwards through the thorax on the left side of the vertebral column; this portion is called the thoracic aorta; on its way it gives off branches right and left to the intercostal muscles, and also branches to nourish the lungs and other contents of the thorax; it then passes through the diaphragm and enters the abdomen, where it is called the abdominal aorta; through the abdomen the course is more to the front of the vertebral column. The first important branch given off from the abdominal aorta

is the cœliac axis, which is short and immediately divides into three branches, the gastric artery for the stomach, the splenic artery for the spleen, the hepatic artery for the liver; a little lower down branches are given off to the kidneys, right and left renal arteries, and also branches to nourish the mesentery and the intestines. When the abdominal aorta reaches the level of the fourth lumbar vertebra it bifurcates, forming the right and left common iliac arteries. These are about $2\frac{1}{2}$ inches long, each of which in turn bifurcates to form an external and internal iliac artery. The internal iliac takes a downward and backward course into the pelvis, whilst the external iliac takes a forward course into the pelvis and passes under Poupart's ligament into the thigh, then downwards on the inner side of the femur where it is called the femoral artery, through the space behind the knee where it is called the popliteal artery, and where it bifurcates into the anterior and posterior tibial arteries. The anterior tibial artery passes down the front of the tibia and supplies the upper or dorsal part of the foot and the toes; the posterior tibial artery passes down behind the tibia and supplies the inner ankle and plantar portion of the foot. (*Systemic Circulation.*)

There are certain parts of the body which have an independent circulation of their own, the venous blood of which is not carried at once to the vena cava; the blood carried to the stomach, intestines, spleen and pancreas being gathered into veins

which unite into in a single trunk, the portal vein or vena portæ.

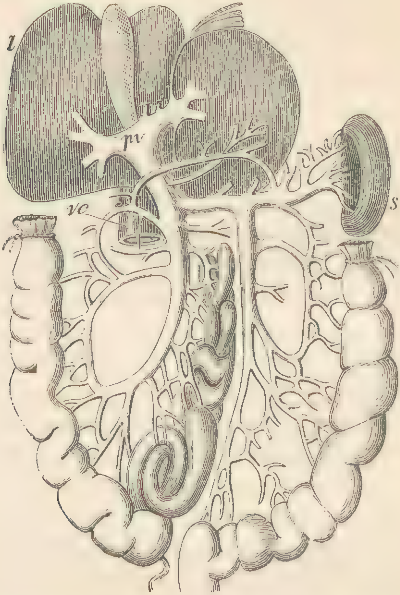

Fig. 4.—Diagram of the Portal Vein (*pv*) arising in the alimentary tract and spleen (*s*), and carrying the blood from these organs to the liver.

The *portal vein* distributes its blood to the liver, mingling it with that supplied to the capillaries of the same organ by the hepatic artery; from these capillaries it is conveyed by small veins which unite

into a large trunk, the hepatic vein which opens into the inferior vena cava. (*Portal Circulation.*)

We can therefore see that the function of the *pulmonary circulation* is the aëration of the blood in the lungs; that the function of the *systemic circulation* is to convey blood to all parts of the body; that the function of the *portal circulation* is the elaboration of nutriment.

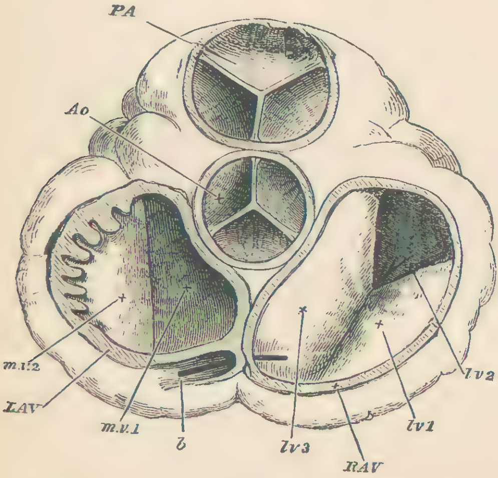

Fig. 5.—The Orifices of the Heart seen from above, both the auricles and the great vessels being removed. (Huxley.)

PA. Pulmonary artery and its semilunar valves.
Ao. Aorta and its valves.
RAV. Tricuspid, and *LAV.* Bicuspid valves.

The heart has no influence over the lymphatics; they are under the control of the nervous system; fluid passes along them by capillary attraction, assisted by the pressure of the actions of the muscles. The walls of the heart and blood-vessels are under the control of special branches of the sympathetic system, the *vaso-motor nerves*, of which some fibres have the special function of dilating, others of contracting, the vascular walls.

CHAPTER VI

THE RESPIRATORY ORGANS

RESPIRATION is carried on by means of :

(1) The mouth.	(4) The trachea.
(2) The nose.	(5) The bronchi.
(3) The larynx.	(6) The lungs.

Accessory to these organs are :

(1) The diaphragm.

(2) The intercostal muscles.

The *mouth* and *nose* are lined with a mucous membrane which is highly vascular, so that the air passing through them is both moistened and warmed before it enters the air passages.

The *larynx* contains the organ of voice, and is situated at the base of the tongue and at the upper part of the trachea ; it is composed of nine cartilages connected by ligaments and moved by numerous muscles, lined by mucous membrane and supplied with nerves and blood-vessels. The chink, or opening, into the larynx is called the *rima glottidis*, and it is guarded by the *epiglottis*, a thin lamella or plate of elastic fibro-cartilage, shaped like a leaf and situated at the back of the tongue.

During respiration the epiglottis remains in a vertical position, but in the act of swallowing it is drawn down over the glottis to prevent any foreign body entering the air passages :

The nine cartilages of the larynx are :

1 Thyroid.	2 Arytenoid.
1 Cricoid.	2 Cornicula laryngis.
1 Epiglottis.	2 Cuneiform.

The function of the larynx is to protect the vocal cords and the entrance to the air passages.

There are four *vocal cords*, two *false* and two *true*. The two superior or false cords are folds of mucous membrane attached in front to the angle of the thyroid cartilage and behind to the anterior surface of the arytenoid cartilages. The two inferior or true vocal cords are strong fibrous bands covered with mucous membrane, and are similarly attached.

Between the false and true vocal cords is a space or cavity called the ventricle of the larynx. The anterior part of this ventricle leads up by a narrow canal into a pouch of mucous membrane called the laryngeal pouch.

If any foreign substance passes through the glottis it will very likely lodge in this pouch and produce irritation and coughing until it is ejected. The vocal cords may be said to act as janitors to the respiratory organs.

The *trachea*, or *windpipe*, is a cartilaginous and membranous tube, about $4\frac{1}{2}$ inches long,

two-thirds of which consists of imperfect cartilaginous rings, and the remainder of fibrous membrane. The fibrous membrane is chiefly at the

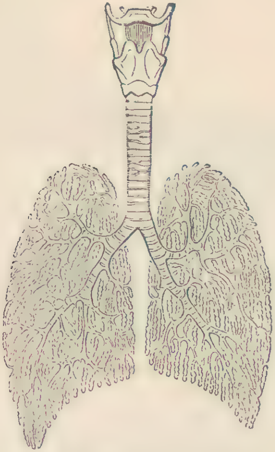

Fig. 6.—Diagram of the Respiratory Organs. The windpipe leading down from the larynx is seen to branch into two large bronchi, which subdivide after they enter their respective lungs.

back where the trachea comes into contact with the œsophagus; there are from sixteen to twenty of these rings connected by membrane and extending from the level of the fifth cervical to the level of the third dorsal vertebra. Hear the trachea bifurcates into the two bronchi, one for each lung.

Each *bronchus* after entering its lung divides and subdivides dichotomously (by constant double fork-

ing), the smaller branches being called bronchial tubes; these are elastic and cartilaginous and are lined with mucous membrane.

Fig. 7.—Transverse section of part of the wall of a medium-sized Bronchial Tube. × 30. (F. E. Schultze.)

a. Fibrous layer containing plates of cartilage, glands, &c.
b. Coat composed of unstriated muscle.
c. Elastic sub-epithelial layer.
d. Columnar ciliated epithelium.

When the tubes become as small as one-forty-eighth of an inch in diameter, they lose their cartilaginous property and finally terminate in elongated muscular dilatations called intercellular passages. These open into air cells which form the ultimate tissue of the lung. The walls of these air cells are a fine membrane, over which are spread the capillaries of the pulmonary artery. It is here that the venous blood is brought into contact with oxygen and so purified of its carbonic acid gas.

The *lungs* occupy the greater part of the cavity of the thorax or chest, and are situated to the right and left of the heart.

Each lung is invested by a serous membrane called the *pleura*, which encloses the organ as far as its root and is then reflected upon the inner surface of the thorax.

The portion of the pleura that invests the lung is called the *pleura pulmonalis*, or *visceral pleura*, whilst that portion which lines the inner surface of the thorax is called the *pleura costalis*, or *parietal pleura*; the space between these two portions is called the *pleural cavity*.

In *pleurisy*, or inflammation of the pleura, this cavity is filled with a serous fluid, the product of inflammation; in more severe inflammation it is filled with pus, the product of a further degree of inflammation called suppuration (*empyema*).

The tissue of the lung itself is very elastic and of a light, spongy, porous character; when healthy it floats in water, but in the fœtus, before respiration takes place, and also in certain diseases of the lungs, such as congestion and inflammation, which render the lung solid, it sinks.

When pressed between the fingers the lung imparts a peculiar sensation together with a crackling sound, caused by the air in the tissue. In infancy the lung is a pale rose-pink colour, but as life advances it becomes more or less mottled with grey.

The *right lung* is divided into three lobes; it is conical in shape, with its base below, concave and semi-lunar in form as it rests on the arch of the diaphragm. The apex forms a blunted point, reaching into the root of the neck above the margin of the first rib. The anterior surface is smooth and convex, its inner border concave; the posterior border is rounded and broad and is received into the deep groove formed where the ribs articulate with the dorsal vertebræ; the anterior border partly overlaps the heart. The right lung is broader than the left owing to the position of the heart: it is also shorter by an inch to accommodate the liver; but it is, nevertheless, of greater capacity.

The *left lung* is smaller, longer, and narrower than the right, and is divided into two lobes. Its base, apex, surface, and borders, correspond with those of the right lung.

A little above the middle of the inner border of each lung is its *root*, by which the lung is connected with the heart and trachea.

This root is formed by the bronchus, pulmonary arteries, nerves, and lymphatics; here also the pulmonary veins pass out.

The root of the right lung is situated behind the superior vena cava and the upper part of the right auricle; the root of the left lung lies beneath the arch of the aorta.

As already stated, the lungs are very elastic, so that the amount of air they contain varies. In a normal condition they are capable of holding

about two hundred cubic inches of stationary air, together with about thirty cubic inches of tidal air (or about five to seven pints of air).

The quantity of air taken in after a very deep inspiration is about one hundred cubic inches, or about two and a half pints. Air received into the lungs undergoes four changes:

(1) It is rendered warmer and moister by passing over the mucous membranes lining the air passages.

(2) Its proportion of CO_2 is increased.

(3) Its oxygen is diminished.

(4) Its organic matter is increased.

Air taken into the lungs should consist of oxygen one-fifth and nitrogen about four-fifths and a minute proportion of CO_2, and watery vapour, H_2O.

Air exhaled from the lungs will be found to contain CO_2 in excess, no oxygen, a certain amount of NH_4HO and some watery vapour. The CO_2 given off is in proportion to the organic matter.

Chief uses of Oxygen inhaled by the Lungs.

(1) As the oxygen enters the air-cells, it is absorbed by the capillaries which permeate their walls; it enters into chemical combination with certain constituents of the blood, especially C, and forms CO_2, which is given off by expiration.

(2) Some of the oxygen is carried along the blood stream by means of arteries and capillaries and comes into contact with waste material—*i.e.*, urea and uric acid, which are oxydised forms of

effete muscles and tissue, and which must be removed from the body.

(3) The remaining good purpose served by the oxygen which the vessels absorb in the lungs is, to convert part of the surplus fat and starch into CO_2 and as no chemical combination can take place without heat being evolved, this change tends to maintain the warmth of the body. In healthy adults the act of respiration takes place about eighteen times per minute or once to every four beats of the heart.

In women and children respiration is quicker and louder than in men; in children averaging twenty-five per minute.

In men respiration is more easily perceptible in the lower part of the chest; in women in the upper part.

It is well to observe that the main source of oxygen in the atmosphere is green plants. The chlorophyll which they contain, under the influence of sunshine, has the special property of acting upon the CO_2 and H_2O which are in the air, in such a way as to fix the Carbon and Hydrogen and set free the Oxygen, which is in turn given back to the air. Animals eagerly inhale this Oxygen and in return for it give off Carbonic Acid Gas, so that by this beautiful and simple interchange of gases animal and vegetable life are sustained, each by the other; each at the expense of the other, but with mutual advantage.

CHAPTER VII

THE DIGESTIVE ORGANS

In order that we may have sufficient nourishment for the blood supply of our bodies, it is necessary that our blood should be renewed; this is effected by means of the digestive tract or alimentary canal (Lat. *alimentum* = nourishment).

The *alimentary canal*, or passage through which food is conveyed to the tissues, begins at the mouth and ends at the anus. It is a musculo-membranous tube comprising the:

(1) Mouth.	(4) Stomach.
(2) Pharynx.	(5) Small intestine.
(3) Œsophagus.	(6) Large intestine.

To these may be also added what are sometimes called the accessory organs of digestion;

(*a*) The teeth (thirty-two in number).

(*b*) The salivary glands (three pairs).

(1) The parotid glands (in front of the ear).

(2) The submaxillary glands (beneath the jaw).

(3) The sublingual glands (under the tongue).

The word *digestion*, which comes from the Latin

digerere, to carry into different parts, signifies the separation, by various chemical processes, of the

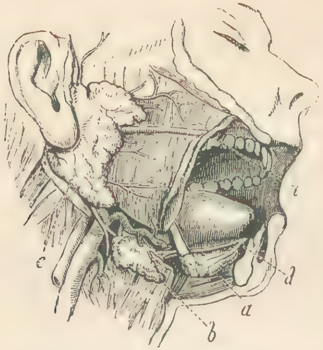

Fig. 8.—A Dissection of the side of the face, showing the Salivary Glands.

a. Sublingual gland.
b. Submaxillary glands with their ducts opening on the floor of the mouth beneath the tongue at (*d*).
c. Parotid gland and its duct, which opens on the inner side of the cheek.

nourishing part of the food from that which is not nourishing, and the absorption of such nourishment after it had been dissolved or broken up into minute globules suitable for the maintenance of the tissues. This is brought about by—

(1) Mechanical action.
(2) Chemical action.
(3) Absorptive action.

Food is taken into the mouth and wrought upon by the mechanical action of the teeth; at the

same time it comes into contact with the saliva, which is a fluid secreted by the salivary glands and which is being perpetually poured into the mouth to keep it moist.

On the introduction of food into the mouth, the flow of saliva is immediately increased, and it not only softens the food but acts chemically upon the starchy portions of it by converting them into sugar.

Now in the saliva there is a substance called ptyalin, which acts as a ferment (*ferment* = something which in very small quantities is able to produce great changes in large quantities) and which having a chemical affinity for starch, takes hold of it and converts it into a species of sugar, called dextrine. Starch is not readily absorbed, dextrine is; hence the reason of the change.

Food, after being masticated by the teeth and acted upon by the saliva, is collected into a bolus and passed by the tongue to the back of the mouth; the uvula or extremity of the soft palate is pushed backwards to close the cavity leading to the nose; the epiglottis at the root of the tongue closes over the glottis to prevent anything entering the larynx, thus the bolus of food is passed over it, seized by the muscles of the pharynx, and conveyed by means of the œsophagus or food carrier into the stomach.

The greater part of the alimentary canal consists of three coats—

(1) The peritoneal coat (a perfectly smooth surface).

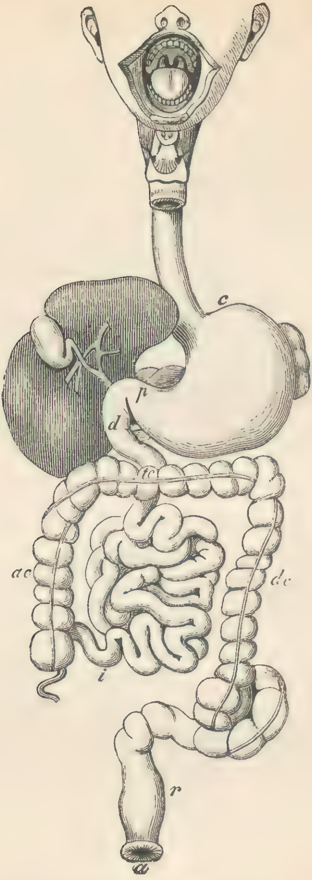

Fig. 9.—Diagram of Alimentary Tract, &c. Angles of mouth slit to show the back of the buccal cavity and the top of the pharynx.

c. Cardiac.
p. Pyloric parts of stomach.
d. Duodenum.
i. Jejunum and ilium.
ac. Ascending colon.
tc. Transverse colon.
dc. Descending colon.
r. Rectum.
a. Anus.

(2) The muscular coat (composed of fibres).

(3) The mucous membrane (for absorptive purposes).

Food is conveyed along the alimentary canal by peristaltic action, which is movement in successive jerks caused and controlled by the longitudinal and transverse action of the muscular contraction of the walls of the canal.

The *stomach* is a muscular oblong bag, capable of holding two to three pints, and is situated in the upper left side of the abdomen immediately below the diaphragm, to which it is attached by a ligament.

That end of the stomach communicating with the œsophagus is called its cardiac opening; the outlet at the further end is termed the pylorus or pyloric opening. The space between these two openings is called the lesser curvature, whereas the lower border is called the larger curvature.

The mucous membrane of the stomach is arranged in tubular rows or folds called *rugæ,* in which lie a number of glands, the function of which is to secrete gastric juice and mucus, which serves to moisten and protect the membrane itself.

The gastric juice has been proved to consist of water, saline matter, hydrochloric acid, and pepsin. The hydrochloric acid supplies the acid medium in which alone pepsin can be effective.

The moment food reaches the stomach its muscular walls contract and set up a churning motion,

which rolls the food pulp from side to side, thus bringing it into contact with the gastric juice, which acts on the albuminous portions of the food and reduces them to a semi-fluid condition. If food not thoroughly acted upon by the juices reaches the pyloric end, it causes the valve to close by contraction, but when the process of digestion is properly completed, the food reduced to a greyish semi-fluid mass, called *chyme*, passes through this valve into the intestine.

All liquids are absorbed in the stomach by minute vessels which ramify through the walls, therefore food, such as soup, beef-tea, &c., is absorbed at once and not passed through the pylorus.

The small intestine measures twenty feet in length, and is held up by a reflection of peritoneum, called the mesentery. It is divided into three parts—

(1) The duodenum (about ten inches long).
(2) The jejunum (nearly three-fifths).
(3) The ileum (nearly two-fifths).

In the interior of the duodenum we find the mucous membrane drawn up into a large number of transverse folds, and presenting a velvety appearance from the fact of its being covered by minute papillæ termed *villi*. In the centre of each villus we find the true absorbent vessel, which is called a *lacteal*."

The lacteals are the lymphatics of the intestines. These folds, or valvulæ conniventes, serve two purposes; first, to delay the food pulp in its passage,

and, secondly, to afford a greater surface for absorption. During its passage through the duodenum food is subject to two agencies—the pancreatic juice and the bile.

The pancreatic juice is a fluid secreted by the pancreas; it acts upon all foods, but its chief chemical property is the same as that of the saliva. If any starchy matters have been allowed to pass through the mouth untouched by the saliva they are seized upon by the pancreatic juice and converted into sugar. Albumens which may have escaped the action of the gastric juice are converted into peptones; and fats are emulsified.

Bile is a fluid secreted by the liver (one to two pints in twenty-four hours, a certain portion of which is stored up in the gall-bladder). It is carried from both of these by means of ducts—the hepatic duct and the cystic duct—and these form a common duct which opens into the duodenum close by the pancreatic duct.

At the same time, from the surface of the intestine itself, a peculiar, half liquid, slimy mucus exudes, called intestinal juice (succus entericus). With these three juices the chyme mixes as it passes on, loses its acid character and becomes alkaline, assumes a milky appearance, and is then called *chyle*. The bile has three functions—

(1) It works upon the fatty portions of the food; forming them into an emulsion, in which form alone they can be absorbed.

(2) It acts as an antiseptic, and prevents decomposition of the food-pulp.

(3) It promotes the peristaltic movement of the intestines.

The chyle is first conveyed to numerous glands in the neighbourhood of the small intestine, called *mesenteric glands*. The lacteal vessels proceeding from these glands empty themselves into the receptacle of the chyle, which is a large cavity, opposite the last dorsal vertebra.

From this cavity a duct, called the thoracic duct, ascends upwards through the thorax and unites with the venous system at the innominate vein on the left side below the neck. At the opening into the vein there is a valve which allows the chyle to flow into the blood-stream, but not to regurgitate. As the chyle passes up the thoracic duct the fat diminishes, and minute white bodies, or cells, make their appearance, growing more and more like blood corpuscles.

By the addition of bile to the chyme the contents of the duodenum are rendered alkaline. When fat in its passage through the body comes into contact with alkalies it becomes soapy and suitable for absorption.

Distributed over the mucous membrane of the small intestine are Peyer's patches—groups of glands somewhat globular in character. They are the seat of inoculation in typhoid fever. The

typhoid bacillus fixes his "habitat" there, and thrives and multiplies. When food has passed through the small intestine it reaches the large intestine, which is divided into—

(1) The cæcum.
(2) The colon (ascending, transverse, descending).
(3) The rectum.

The opening of the ileum into the cæcum is guarded by the ileo-cæcal valve, and close to this valve is a blind ending of the cæcum, called the vermiform appendix (in some persons, particularly liable to inflammation = appendicitis).

The last coil of the descending colon is called the sigmoid flexure, also sometimes the seat of disease. The structure of the large intestine is similar to that of the small, only it is not provided with villi, as the nourishing part of food has been mainly absorbed before entering it.

Food in the small intestine is fluid, gradually becoming firmer, but after passing the ileo-cæcal valve it becomes solid and slightly acid again, owing to the presence of lactic acid, the purpose of which seems to be to dissolve out any remaining gluten (especially vegetable matter) which the contents of the bowel may contain, thus completely exhausting it of all nutrition.

The residue, being non-nutritious, is gradually passed along the colon as fæcal matter, and, coming down the rectum, is finally discharged by the anus.

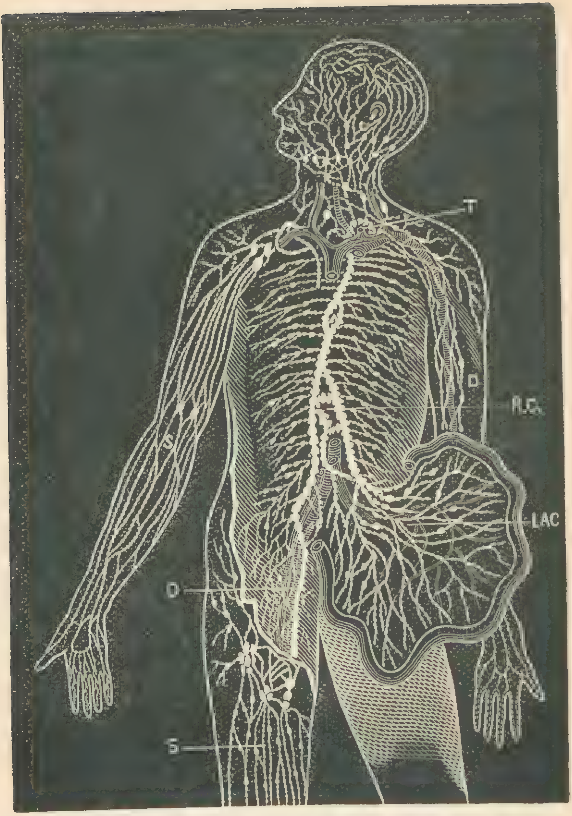

Fig. 10.—Diagram showing the course of the Main Trunks of the Absorbent System. The lymphatics of lower extremities (D), meet the lacteals of intestines (LAC) at the receptaculum chyli (R.C.), where the thoracic duct begins. The superficial vessels are shown in the diagram on the right arm and leg (S), and the deeper ones on the left arm (D).

The glands are here and there shown in groups. The small right duct opens into the veins on the right side. The thoracic duct opens into the union of the great veins of the left side of the neck (T).

The glands of the large intestine secrete mucus to lubricate its surface, and to further the progress of the food.

The peculiar odour of fæcal matter is ascribed to the presence of indol, which probably comes from the pancreas.

Absorption of Constituents of Food.

Sugars and Starches are absorbed either in the mouth, stomach, or small intestine.

Fats are absorbed chiefly by the lacteals of the small intestine.

Albumens are mainly altered in the stomach, being changed into peptones, and acted upon by the hydrochloric acid of the gastric juice.

Salts, if soluble in acid, are absorbed in the stomach; if in alkali, in the small intestine.

Water is absorbed gradually throughout the entire length of the canal.

Alcohol, when taken into the system, is carried direct to the liver, and absorbed by the blood-vessels.

CHAPTER VIII

THE EXCRETORY ORGANS

THE *organs* of *excretion* are those which separate impure matters from the blood and eliminate them from the body.

The principal excretory organs are—

(1) The lungs.

(2) The kidneys.

(3) The skin.

The lungs and skin excrete volatile matters, carbonic acid gas, and watery vapour.

The kidneys excrete solid matters, such as urea, uric acid, sundry animal products such as colouring matter, saline and gaseous substances; all held in solution by a large quantity of water.

The *lungs* belong more correctly to the respiratory organs, but are important also as excretory organs, for the oxygen which we inhale combines with the carbon, derived from waste products in the blood, and forms a poisonous gas, CO_2, or carbonic acid gas, which with water is exhaled or excreted

as breath. From impairment of the action of the lungs we find that—

(1) Blood is not oxydised.

(2) The body has a tendency to cool.

If respiration ceases we find that a person dies in two or three minutes from carbonic acid poisoning.

Dyspnœa, or difficulty of breathing,

Asphyxia, or *Apnœa* (= cessation of breathing), show interference with the pulmonary circulation, and death in such cases would be due to carbonic acid poisoning.

Carbonic acid poisoning especially affects the nervous system, hence the violent delirium which may accompany pneumonia; and some have attributed the vivid pictures which are presented before the mental eyes of a drowning person to the same cause.

The Kidneys.

The kidneys are placed in the loins, one on each side of the vertebral column; they are fixed behind to the muscles of the back and are held in place in front by a fold of peritoneum. (The serous membrane, which lines the abdominal and pelvic cavities, and invests the viscera contained therein.)

If under any circumstances this fold of peritoneum gets stretched, it allows a kidney to fall forward and become displaced; it may even find its way down to the pelvis (as in floating kidney).

The kidneys are the principal organs of the body for eliminating certain secretions, which if retained in the body prove injurious.

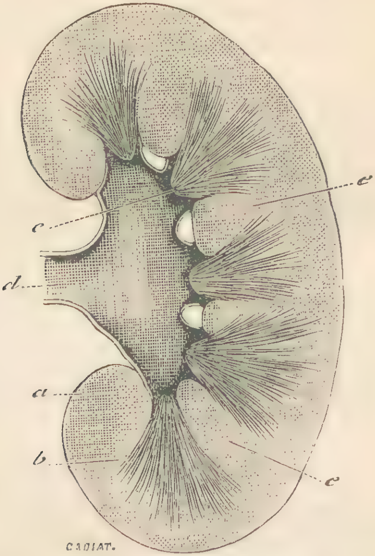

Fig. 11.—Section of Kidney of Man. (Cadiat).

a. Cortical substance composed chiefly of convoluted tubules and Malpighian bodies.
b. Pyramids of medullary substance, composed of straight tubes and loops of Henle, radiating towards cortex.
c. Papillæ, where the tubes open into pelvis.
d. Commencement of ureter, leading from central sac or pelvis.

Each kidney is about four inches in length,

two to two and half inches in breadth and one inch in thickness. A well-developed healthy kidney weighs about six ounces. In the middle of the concave side of each kidney there is a notch called the hilum, which allows the passage of vessels, nerves, and urine (by excretory duct) into and out of the kidney.

When a vertical section is made of the kidney we see that it consists of a central cavity surrounded by kidney substance. This central cavity is called the sinus and is lined by a prolongation of the fibrous coat which surrounds the exterior of the kidney and which also enters it through the hilum. The ureter or excretory duct dilates into a basin-like cavity called the pelvis; into the pelvis sundry conical elevations project, called pyramids. Their summits present multitudes of minute openings, terminations of the urinary tubules, of which the thickness of the kidney is chiefly made up. If the tubules be traced from their opening to the outer edge of the kidney, they are found at first to lie parallel with each other in bundles, which radiate towards the surface and subdivide as they go, but at length spread out irregularly and become interlaced. From this circumstance the medullary or middle part of the kidney looks different from the cortical or superficial part, which latter is more abundantly supplied with vessels and is therefore darker in colour.

The greater number of the urinary tubules

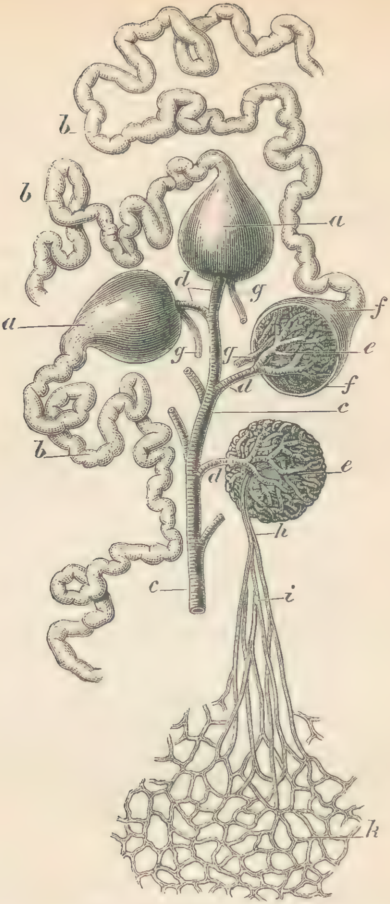

Fig. 12.—Glomeruli of the Kidney with the origin of the Tubuli Uriniferi.

a, *a*. Capsules of Malpighi, enclosing the glomeruli; *b*. Contorted portion of the tubuli; *c*. Straight or interlobular arteries; *d*. Afferent vessels, conveying blood to the Malpighian corpuscles; *e*. Glomeruli formed by the ramification of the afferent arteries; *f*. Capsule from which a portion has been removed to show the glomerulus within it; *g*. Efferent vessels; *h*. Efferent vessels, the divisions of which *i* break up into the capillary network, *k*, of the kidney.

ultimately terminate towards the surface in dilatations called Malpighian capsules.

Into each capsule enters a small renal artery, which breaks up into a bunch of capillary vessels, called a glomerulus, which nearly fills the capsule. Blood is carried from the glomerulus by a small vein which runs into other veins and these finally empty themselves into the inferior vena cava. It is obvious that the more full the glomerulus of blood, the more rapid will be the escape of urine. Hence it is found that when blood flows freely to the kidney, the urine is secreted (formed) freely, but that when the blood supply to the kidneys is scanty, the urine is also scanty. The vein which leaves the glomerulus is much smaller than the artery (which is unusual), and that also accounts for a slower progress of the blood.

The function therefore of the kidneys is:

(1) To get rid of the water in the body by filtration.

(2) To get rid of albuminous matter not used up in digestion.

Normal urine should be acid, clear, of a yellow colour, and should contain no albumen and no sugar. It does contain urea in solution, a small quantity of uric acid and sundry other animal products of less importance. Specific gravity 1020.

Urea is the essential solid constituent of urine, considered to be a result of the action of the liver upon some of the nitrogenous substances in the

blood. Urea and uric acid are both composed of carbon, hydrogen, oxygen, nitrogen, but urea is far the more soluble in water and greatly exceeds the uric acid in quantity; there being 500 grs. of urea to 10 or 12 grains of uric acid. The total solids excreted by the kidneys daily equals about 1000 grains, of which one-half is urea.

The Skin.

The skin forms a polished surface to all the

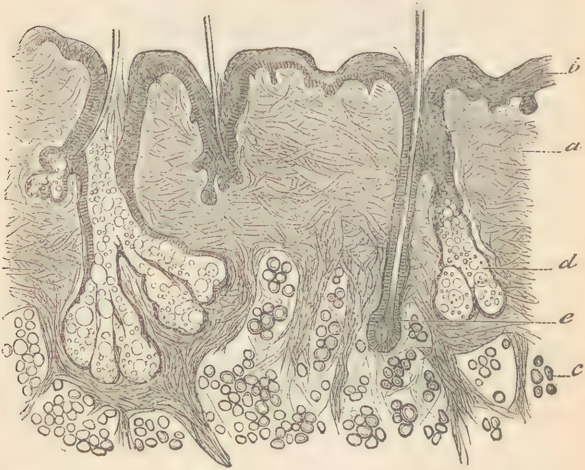

Fig. 13.—Section of Skin showing the roots of three hairs and two large sebaceous glands (*d*). (Cadiat.)

body but is variously constituted in different parts. The skin consist of three layers—

(1) Epidermis, cuticle, or scarf skin.
(2) Derma, vera cutis, true skin or corium.
(3) Subcutaneous tissue, the amount of which determines the mobility of skin.

The *epidermis* is composed of cells which have no blood-vessels, no nerves, no glands; it is a purely sheathing structure to protect the second layer or derma. Epithelial cells are flat and fit together like tesselated pavement. At the lower part of the epidermis is the basement membrane, rete mucosum, or rete Malpighii, composed of oval cells and containing pigment in the form of small granules.

The *derma*, or *true skin* may be divided into two layers, the upper layer being composed of papillæ, conical in shape, well seen on the back of the tongue; each papilla has its blood-vessel, a large distribution of nerves and dense tactile organs, which readily convey impression to the brain. Each papilla is also the rudiment of a hair. The second layer of the derma is composed of connective tissue bands interlacing with each other, permeated by blood-vessels, glands and fat.

The skin has two sets of secreting organs—

(1) Sudoriparous, or sweat glands.
(2) Sebaceous (*sebum* = lard) or fat glands.

These latter are connected with the hair follicles, and open on the surface of the skin, thus keeping it smooth and moist; muscles are attached to the sac containing the hair follicle, which contract from

cold or fright, producing goose skin. In deeper parts of the skin, where the connective tissue is loose, fat or adipose tissue collects, and serves to economise heat, to facilitate movement, and acts also as a reserve fund.

The function of the skin is the perspiration (breathing through) of aqueous vapour from the body. Insensible perspiration is always going on; about three pints per diem are passed off.

Sensible perspiration is due to exertion, activity, indulgence in drink, or to the emotions; thirty pints and more may be passed off daily.

Perspiration is of great importance, because it means loss of heat to the body and therefore affects the temperature.

The amount of perspiration excreted daily from the skin in the form of watery vapour and CO_2 is more than that excreted by the lungs; 11 parts being given off by the skin to 7 by the lungs.

The body also throws off daily by the skin solid matter about 300 grains, CO_2 about 400 grains; the solid matter is largely urea.

This is the function of the sudoriparous glands. The skin is chiefly an excretory organ, but has also secretory and absorptive powers. A certain amount of oxygen is absorbed by the skin.

CHAPTER IX

THE SECRETORY ORGANS

By secretion is meant the separation of a special substance from the blood for further use in the economy of the body.

A gland is an organ, or part of the body, of which the special function is secretion.

The principal organs of secretion are:

(1) *The liver.*

(2) *The pancreas.*

(3) *The salivary glands.*

(4) *The mucous glands.*

The *liver* is a large reddish-brown organ, situated in the right hypochondriac region, and extending across the epigastrium to the left hypochondriac region; its transverse diameter is ten to twelve inches, and it is about three inches thick. The liver is the largest and heaviest gland in the body, and weighs from fifty to sixty ounces.

It consists of five lobes, sub-divided into lobules. These lobules are covered with areolar tissue and are held together by it.

This areolar or connective tissue of the liver and its vessels and nerves are nourished by a special artery from the abdominal aorta, the *hepatic artery.*

The liver is supplied with the blood from which it derives its secretions by the *portal vein*, a vessel which collects blood from the stomach, spleen, and pancreas.

The portal vein divides and sub-divides in the liver till it forms a plexus of minute vessels from which originate the radicals of the *hepatic vein*, a vessel which conveys blood from the liver to the inferior vena cava.

The spaces between the blood-vessels of the liver are filled with minute cells, about one thousandth of an inch in diameter, called *hepatic*, or *liver cells.* The blood capillaries run between these, and all changes which occur in the blood as it circulates through the liver are brought about by the action of the cells, which are separated from the blood only by the exceedingly thin walls of the arterioles.

The materials which are separated from the blood appear to pass through the liver cells to another set of capillaries, called *bile capillaries.* These unite to form small biliary ducts which by further union form two larger ducts. Of these, one conveys the bile from the right lobe, the other from the left lobe; both uniting to form the *hepatic duct.* The gall bladder is connected with

this tube by a duct of its own called the *cystic duct*, and these two unite into the common duct which passes directly into the duodenum.

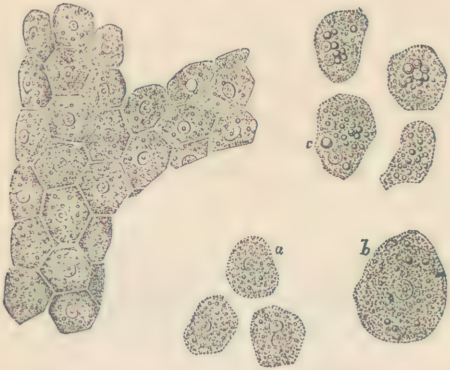

Fig. 14.—Cells of the Liver. One large mass shows the shape they assume by mutual pressure.

a. The same free, when they become spheroid.
b. More magnified.
c. During active digestion containing refracting globules like fat. (Carpenter.)

The *gall bladder* or reservoir of the bile is a pear-shaped bag lying on the under surface of the liver, and kept in place by peritoneum, which loosely invests the whole of the liver. Secretion of the bile is continuous, but it is retarded during fasting and increased on taking food, the quantity secreted in twenty-four hours being about $1\frac{3}{4}$ pint. Sometimes this is reabsorbed into the blood, owing to obstruction in the hepatic duct, and the result

is a symptom called jaundice or icterus, characterised by the yellow colour of the skin.

The *bile* has three functions:

(1) It works upon the fatty portions of the food.

(2) It acts as an antiseptic, and prevents the decomposition of the food pulp.

(3) It promotes the peristaltic movement of the intestines.

The liver also forms a substance, called glycogen, resembling starch and sugar in composition. This is carried off from the liver by the hepatic vein to the inferior vena cava, and thence to the lungs, where it is oxidised (converted into CO_2 and H_2O), thus helping to maintain the temperature of the body.

Bile is composed of biliary acids, fat, cholesterin, colouring matter, and salts.

The *pancreas*, another large secretory organ, is situated behind the stomach, and is about 7 inches long and 4 inches wide in the widest part.

The pancreas secretes a juice which passes by a duct into the duodenum, 12 to 16 ounces daily.

Pancreatic juice resembles saliva, and also acts on starchy portions of the food which have escaped the influence of ptyalin in the mouth; it has also a peculiar action over fatty matters and albumens, it aids digestion, and gives the chyle its milky appearance (see p. 63).

The *salivary glands* are arranged in three pairs:

2 *Parotid*, in front of the ear.
2 *Submaxillary*, beneath the jaw.
2 *Sublingual*, under the tongue.

The secretion of the saliva is continuous, about 2 lbs. in 24 hours, and is excited on taking food or by the introduction of anything into the mouth, and by mental impressions.

The active principle of the saliva is called ptyalin, and possesses the property of changing the starchy portions of food into sugar.

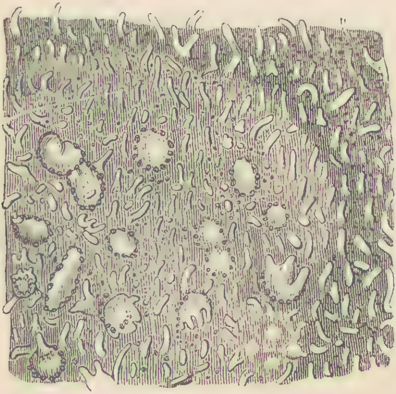

Fig. 15.—Portion of the Mucous Surface of the end of the Human Ileum, moderately magnified, showing the *Peyerian Glands*, the orifices of the follicles, and the villi.

Saliva serves to keep the mouth moist, helps the movements of the tongue and mastication of the

food, and softens the food pulp, so that it may be easily swallowed.

The salivary glands are not active until the fourth or fifth month of infantile life.

Mucous glands separate from the blood a watery fluid called *mucus*, which serves to keep the mucous membranes moist.

By its lubrication of the alimentary canal, it aids digestion and promotes peristaltic action.

There are certain other glands in the body which have no duct, as the *spleen* and *thyroid gland*. Such organs are termed *ductless glands*, and are probably engaged in the formation of the blood.

We know that atrophy of such glands causes disease, although their special function is not yet fully determined.

Gland forms may be classed as *tubulated* or *lobulated; tubulated* when the secretion is conveyed from the gland by minute tubes, and *lobulated* if composed of a group of sacs or lobules, communicating with a common outlet. Although glands vary considerably in form, yet they are all constructed on one general principle. All consist of a secreting membrane which is closely surrounded by a network of minute blood-vessels.

CHAPTER X

THE MUSCULAR SYSTEM

The *muscular system* occupies little less than half the weight of the body and 75 per cent. of muscle consists of water.

Muscle may therefore be said to consist of two parts, the *fibrous* or *solid* part, which is nutritious; and the *serous* or *watery* portion.

Muscles form the fleshy covering to the framework of the body; they are divided into two classes, according to their structure and function.

The actions of muscles are either *voluntary* or *involuntary*; the former are governed by nerves from the *cerebro-spinal* system.

Those muscles *not* under the power of the will are termed *involuntary* and are unstriped in structure; while those under the power of the will are *voluntary* and striped in structure. (The heart is an exception to this rule, for its muscles are *involuntary* and yet striped, and of a peculiarly fine grain).

Striped or *voluntary* muscles are formed of reddish

fibres called *fasciculi*, enclosed in a delicate membrane, each *fasciculus* consisting of a bundle of fibres running parallel with each other, while the fibres are made up of a number of filaments or fibrillæ,

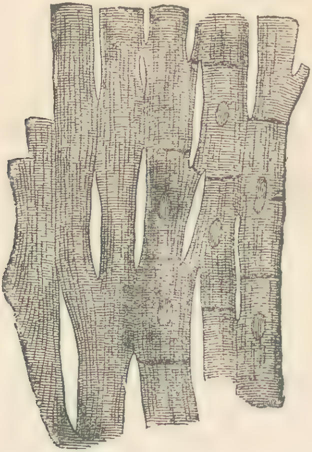

Fig. 16.—Striated Muscle Tissue of the Heart, showing the trellis-work formed by the short branching cells, with central nuclei. (Carpenter.)

enclosed in a sheath of tubular, transparent, elastic membrane called *sarcolemma*. The fibres are cylindrical in shape and marked with very fine lines or striæ; the primitive fibrillæ contain the contractile tissue of the muscle.

Involuntary or *unstriped* muscles are made up of spindle-shaped or fusiform cells, collected into fasciculi, lying side by side, and held together by con-

nective tissue; each fibre in unstriped muscle having a longitudinal appearance. Every muscle consists of two extremities and a body. The attachment of a muscle to a stationary bone is called its *origin* and the attachment to a movable bone its *insertion;* some muscles have a flat termination called *aponeurosis*, such as the muscles of the abdomen. *Involuntary* muscles are not attached to bones, and are found in the intestines, blood-vessels, glands, &c. They have a peculiar movement called *peristalsis* or vermicular contraction. Each muscle must be looked upon as a complete organism in itself, with its own supply of blood, nerves, and lymphatics.

The special function of muscle is its contractility, and this power of contraction is described as its *tone.*

If a muscle has practically lost its power of contraction it may be worked up again by some stimulus such as electricity, irritation, or massage. Muscles are either in a state of rest, activity, or rigor. *Rigor mortis* is the stiffening of the muscles after death; it comes on, as a rule, shortly after death and passes off some hours later. Over-taxation of the muscles produces tremor. In fits and convulsions we see spasmodic contractions of the muscles; a persistent contraction is termed a *tonic spasm*, whilst an intermittent contraction is known as a *clonic spasm.* *Chorea* (St. Vitus' Dance) is spasmodic contraction of certain muscles.

Tetanus (lockjaw), a disease following certain

wounds, is spasmodic contraction of all the muscles. It may also arise idiopathically. Tendons are terminations of muscles by which they hold on to bones; when tendons pass over hard surfaces, as at the elbow and the knee, sacs of fluid called *bursæ* are interposed between tendon and bone to diminish friction.

THE NERVOUS SYSTEM.

The *nervous system* may be divided into two portions, the *sympathetic* and the *cerebro-spinal.* These differ in structure, mode of action, and range of influence.

The *sympathetic nervous system* is a chain of *ganglia* (*ganglion*—a small nervous centre, sometimes called a diminutive brain) extending from brain to pelvis, communicating freely with the cerebro-spinal system and forming masses or *plexuses* (networks of interlacing nerves).

The nervous system is composed of two structures, cells and fibres; by the cells *nerve force* is generated, by the fibres *nerve force* is conducted. Most nerves have two kinds of fibres mingled. Nerves form plexuses, by which these secure a larger connection with the spinal cord.

The nerves of the *spinal column* are thirty-one pairs; each nerve having two roots, an anterior and posterior roots. The functions of the spinal cord are *conduction*, *transference*, and *reflex action.*

The spinal cord is covered by three membranes

called the *dura mater*, *arachnoid*, and *pia mater*; these are continuous with the membranes of the brain. The *brain* is part of the cerebro-spinal

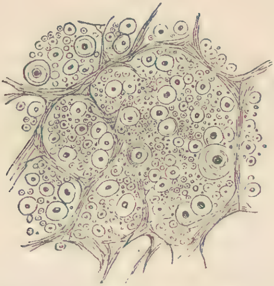

Fig. 17.—Transverse section of nerve fibres, showing the axis cylinders cut across, and looking like dots surrounded by a clear zone, which is the medullary sheath.

system and consists of (1) The cerebrum, or brain proper, which occupies the whole of the upper part of the skull or cranium.

(2) The *cerebellum*, or little brain, lying beneath the hinder part of the cerebrum.

(3) The *medulla oblongata*, or oblong marrow, which may be regarded as a continuation of the spinal cord within the cavity of the cranium, and as forming the connection between the brain and the cord.

The cerebrum and cerebellum are partially divided into two lateral halves or hemispheres by a deep longitudinal fissure. The surface of the hemispheres is divided by a considerable number of

tortuous furrows called *convolutions*, the divisions between the convolutions being termed *sulci ;* the use of these convolutions is to extend the surface of the grey matter.

The brain is composed of grey and white matter ; both in the cerebrum and cerebellum the grey is on the outside and the white inside ; in the spinal cord the white is outside and the grey inside. The grey matter consists of cells and is considered the dynamic part, wherein resides all intellectual power ; the white matter consists of nerve fibres, *efferent* and *afferent,* which cross and re-cross each other in various directions.

At the base of the cerebrum and connected with it are two large ganglionic masses of grey and white matter called the *corpora striata ;* behind them are two bodies of a similar nature, the *optic thalami*, and still further back are four other bodies, a pair on each side, called the *corpora quadrigemina.* All these parts of the brain are connected with each other by numerous nerve fibres ; the fibres from the spinal cord pass upward to the medulla oblongata, those from the posterior columns of the cord going chiefly to the optic thalami, while those from the anterior columns pass to the corpora striata. In the cerebrum and cerebellum and ganglia we find fibres running from their anterior to the posterior ends, while other fibres run transversely and unite corresponding parts on the opposite sides of the brain.

Functions of the different parts of the Brain.

(1) The *cerebrum* is the seat of sensation, volition, emotion, and all those powers which constitute the mind—viz., the will, the intellect and the feelings.

(2) The *cerebellum* is probably the regulator of muscular movements, or in other words, in the cerebellum resides the power of co-ordinate action.

(3) The *corpora striata* are great centres of voluntary movement; not of volition, but of the nervous mechanism by which, when we will with the cerebrum, the influences are sent along the spinal cord to the various muscles.

(4) The *optic thalami* transmit sensory impressions from the spinal cord to the surface of the brain.

(5) The *corpora quadrigemina* receive impressions from the optic nerve and transmit these to the cerebrum, where the sense of vision is then developed.

(6) The *medulla oblongata* and the adjoining part, or *pons Varolii*, are the seat of the nervous influences which regulate swallowing, breathing, and other important involuntary movements. Therefore the medulla oblongata and the pons Varolii are absolutely essential to life.

Other parts of the brain may be cut or mutilated without instant death, but death immediately follows injury to the medulla.

The *spinal cord*, or *marrow*, is a cylindrical column of soft nervous tissue extending from the base of the skull, where it is continuous with the

medulla oblongata, to the region of the loins, on a level with the lower border of the first lumbar vertebra, where it tapers off in threads in the lowest part of the vertebral canal. Its average length is about eighteen inches, and it is divided by an anterior and posterior fissure into two hemispheres, each having a semilunar mass of grey matter, connected by commissural fibres.

From the anterior horns of grey matter efferent nerves pass out; by the posterior, afferent nerves pass in. By means of the grey matter each hemisphere is subdivided into three parts,

(1) Anterior columns. (2) Lateral columns.
(3) Posterior columns.

The weight of the brain is about fifty-two ounces, whilst the spinal cord weighs about one ounce.

Efferent nerve fibres are the channels by which impulses are conveyed from nerve-centres; these impulses result in

(*a*) Motion (motor nerve).
(*b*) Secretion (secretory nerves).
(*c*) Nutrition (trophic nerves).

Afferent nerve fibres convey impressions to nerve-centres—viz.:

(*a*) Contact. (*c*) Temperature.
(*b*) Pressure. (*d*) Pain.

In reflex action both sets of fibres are concerned; the afferent fibres conveying the intelligence, and the efferent producing the effect.

CHAPTER XI

THE ORGANS OF SIGHT, SMELLING, HEARING, AND TASTE

THE *eye* is constructed for the purposes of vision, for which are required a special arrangement of nerves to receive the impressions, certain convex transparent lenses to refract the rays or bend them out of the perpendicular to a focal point, and a protecting envelope to keep the whole in proper condition.

The *eyeball* lies in the *orbit*, a conical cavity in the skull by which it is afforded bony protection; in front it is further protected by an upper and lower eyelid, movable cartilaginous plates covered externally with skin, internally with mucous membrane (*conjunctiva*) and provided with hairs to secure a nicer apposition of the lid edges.

Under the upper eyelid on its outer side lies the *lachrymal gland*, the function of which is to secrete sufficient fluid to keep the eyeball moist. This fluid is collected by a little canal which is formed in the substance of each lid at its inner part.

The upper and lower canals at their point of union are distended into the lachrymal sac and the duct formed by them runs into the inferior meatus of the nose; when the lachrymal gland pours out its

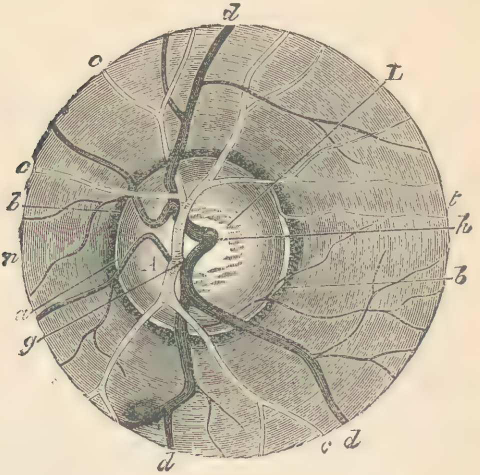

Fig. 18.—Ophthalmoscopic view of fundus of eye, in which the central artery (*g* and *c*) and the corresponding veins (*h* and *d*) are seen coursing through the retina from the optic disc (*A*).

secretions so rapidly that the ducts cannot take it up, it overflows on the cheek in the form of tears. Each eyeball lies embedded in fat, and is supplied with six muscles, *four straight* and *two oblique*, by which rotatory movements are effected.

The *globe* of the eye is nearly spherical and is

covered on its posterior five-sixths by a fibrous membrane (the *sclerotic* coat). This is pierced behind by the *optic nerve* and *ophthalmic artery* and *vein*; its use is protective.

Inside the sclerotic is found a coat also occupying five-sixths of the circumference, and containing pigment and blood-vessels. This is called the *choroid* coat, and at its anterior margin it is folded upon itself into what are called the *ciliary processes;* its use is threefold :

(1) To act as a dark screen.
(2) To serve for the blood-vessels to break up in.
(3) To protect.

The anterior sixth of the globe is filled up by the *cornea,* a convex transparent membrane, the edges of which are tucked in under the sclerotic. Through the cornea can be seen the *iris*, a musculo-membranous pigmented curtain with a central aperture, which latter, owing to some of the muscles being arranged in a vertical and others in a circular direction, is capable of dilatation and contraction according as more or fewer rays of light are required to be admitted behind it.

Behind the iris, with a slight space intervening, lies the *crystalline lens;* a hard bi-convex fibrous body enveloped in a capsule. The lens is suspended in its position by a ligament to which is attached a muscle (*ciliary muscle*) and the arrangement is such that by contraction of the ciliary

muscle the tension of the suspensory ligament of the lens is relaxed and the lens is allowed to become more convex, and consequently capable of bending the rays of light more out of their perpendicular course. The space between cornea and iris (*anterior chamber*) is filled with limpid fluid (*aqueous humour*) and this also extends into the space between the iris and the crystalline lens (*posterior chamber*). The remaining portion of the globe—*i.e.*, behind the crystalline lens—is filled with a gelatinous mass (*vitreous humour*).

Every ray of light in passing through a transparent medium remains in an unbroken straight line if the surface of that medium is plane. But if the surface is otherwise than plane—*i.e.*, if it is *convex* or *concave*—the ray is bent out of the perpendicular, inwards (if it is *convex*) or outwards (if it is *concave*). This is called *refraction*, and the use of these convex lenses in the eye is to bend the rays of light inwards so that they meet at a point on the retina (*focus*). If the rays of light require to be more than usually refracted, as for instance in viewing a near object, the ciliary muscle comes into play, acting in such a way as to allow the crystalline to increase its natural convexity. This is the explanation of the effort which we become conscious of when looking closely at anything. But in people whose eyes are congenitally too short from front to back, the ciliary muscle is in a constant state of contraction in order

that images may be correctly focussed on the retina, and as there is an intimate connection between that branch of the third nerve which supplies this muscle, and that which supplies the internal rectus, it is found that many children are first discovered to have this congenital peculiarity (*hypermetropia*) by developing an internal squint: and moreover in most cases these squints can be cured by a convex spectacle lens which corrects the error of refraction. The headache which a less degree of hypermetropia induces may also be similarly cured.

All rays of light, therefore, striking a convex lens are bent inwards, or refracted, more and more by each lens they pass through, until they meet at a point called a *focus*. It is clear that rays entering the eye are successively refracted by the cornea, aqueous (passing through the pupil), crystalline, and vitreous until they reach a point of focus, as might be gathered from the foregoing description, on the choroid. Yet it is not so; for the optic nerve, after piercing the sclerotic, has the choroid coat reflected upon its trunk, and spreads itself out all over the inner surface of the choroid in a thin coat called the *retina*. This *retina* is made up partially of nervous elements, especially suited for the reception of light-stimuli, and partially of connective-tissue elements, which hold the nervous parts together. The most superficial of the nervous elements are arranged in the form of rods and

cones lying parallel with one another, and in the proportion of four or five rods to one cone. They are the terminal portions of the fibres of the optic nerve, and the vibrations set up in these by the stimuli of rays of light are alone capable of producing, when transmitted to the *corpora quadrigemina*, the phenomena of sight. Obviously, therefore, the following are conditions which may interfere with vision :

(1) Any state of the optic nerve (*neuritis* or *atrophy*) which prevents images being received, or damage to retina, such as detachment, retinitis, pigmentation, and hæmorrhages.

(2) Any condition of the lenses which may obstruct the rays in their passage, or otherwise interfere with their proper focussing on the retina.

Such conditions may be caused by inflammatory states of cornea, iris, aqueous, or vitreous, or by undue hardening of the crystalline from deposits in its substance (*cataract*). But they may also be caused by an eye, which is otherwise healthy, being of improper shape. In an eye too short from before backwards, rays will not be focussed on the retina, but behind it (*hypermetropia*); whilst in an eye too long from before backwards, the rays will be focussed in front of the retina (*myopia*).

It is to meet these two difficulties that extra lenses are put on in the shape of spectacles, so as to cause either greater refraction (*hypermetropia*,

convex glass), or lesser refraction of rays (*myopia, concave glass*).

It has been stated that the muscular fibres of the iris are arranged in two sets, an outer longitudinal and an inner circular. The circular fibres are made to contract by a branch of the third nerve (*motor oculi*), and the ciliary muscle has its supply from the same source. *Atropine* (the active principle of *belladonna*) has the peculiar property, amongst others, of paralysing only those fibres of the third nerve which are within the globe of the eye. Therefore, atropine drops (j to jv grs. to ℥j) are used when it is desired to dilate the pupil and at the same time paralyse *accommodation* (= the change produced in the lens by the action of the ciliary muscle). The effect of atropine lasts some days, but a substance known as *homatropine* is much more transient in its action, as well as more rapid.

Eserine (derived from *Calabar bean*) has the opposite property—viz., of causing pupillary contraction.

Cocain causes slight dilatation, but is used really on account of its anæsthetic effect.

The *nose*, or *organ of smell*, has three chambers, called

Superior meatus, or upper passage.
Middle meatus, or middle passage.
Inferior meatus, or lower passage.

The vertical plate of the ethmoid bone with the vomer separates the *nares* or *nostrils*. The ethmoid,

sphenoid, superior maxillæ, and two turbinated bones help to form the nose, together with several pieces of cartilage. These chambers are lined by a mucous membrane, called the *Schneiderian membrane*, and over the upper third of this mucous membrane of the nose are spread the *olfactory nerves.*

The Schneiderian membrane is highly vascular, and if inflamed produces pain, headache, and running of the eyes, because it is prolonged from the nares into the antrum, frontal sinuses, and con junctivæ.

In disease there is frequently discharge from the nose; *adenoids* are thickening at the back of the nose or throat, which occur chiefly in childhood; *polypus* is a growth in the nose.

The same substance exciting nerves of smell may cause peculiar sensations through the nerves of taste.

The action of external matter produces certain changes on the nerves which are susceptible to an infinite variety of external stimuli.

Although man is inferior to many animals in acuteness of smell, his delicacy of smell is most remarkable.

The *ear*, or *organ of hearing*, consists of a visible part attached to the head, and an invisible part which is fixed in the petrous portion of the temporal bone. It comprises three divisions, called—

(1) External ear.

(2) Middle ear.

(3) Internal ear.

The *external ear* is formed largely by a piece of elastic fibro-cartilage called the *lobe*, over which the skin is stretched with very little areolar tissue. This lobe is elevated and depressed at various parts, in order to facilitate the passage of the vibrations of air, known as *sounds*. The elevations are named

(1) Helix (3) Tragus.
(2) Antihelix. (4) Antitragus.

The depressions are termed *fossæ*, while the little attachment at the bottom is known as the *lobule*; all the fossæ converge to one opening, the *external auditory meatus*, which is a passage $1\frac{1}{4}$ inch in length, $\frac{3}{4}$ inch being cartilaginous, and $\frac{1}{2}$ inch osseous. Its direction is inwards throughout, but also, at first running backwards and upwards, it finally is directed downwards and forwards. The effect of this curve is to protect the more delicate parts within from deleterious injuries from without. The skin of the meatus secretes an oily substance, "*cerumen*," and this mixed up into a ball with hairs, dirt, and epithelial scales is apt to form "wax." The cerumen and the peculiarly long hairs of the skin in this passage are a natural protection against the invasion of foreign matters.

At the inner end of the meatus lies the *middle ear, drum*, or *tympanum*.

The *drum* is a six-sided chamber of about $\frac{1}{3}$ inch in diameter. Its roof shows one or two fissures

into which the dura mater of the brain dips down, and this roof is situated just below the lateral sinus of the dura mater; to these facts is attributed the occurrence of *meningitis*, the result, in some cases, of inflammation of the tympanum. Its floor shows nothing of importance; its anterior wall presents an opening, the upper orifice of the Eustachian tube, through which air is admitted from the pharynx. Its posterior wall presents openings of communication with the mastoid cells in the temporal bone, and into these cells pus is apt to burrow when its exit in other directions is obstructed. Its external wall is formed by a thin membrane known as the *drumhead*.

On its internal wall are various eminences and depressions over which the *facial nerve* takes its course and here gives off that branch to the tongue and submaxillary gland called the *chorda tympani*. Other small nerves also assist in forming a plexus here. Still more important on its inner wall are two openings, one the *fenestra rotunda*, circular, lower down and behind; the other the *fenestra ovalis*, egg-shaped, higher up and in front. Over each of these is stretched a thin membrane.

The membrane of the fenestra rotunda is free, but into that of the fenestra ovalis is fitted a small bone, *stapes* (stirrup). With the outer end of this bone another articulates, *incus* (anvil), and again with the incus a third bone, *malleus* (hammer), forms a joint. The malleus is continued downward

in a bony process which lies against the tympanic membrane; thus a complete chain of bones runs across the tympanum, and these, owing to their solidity, are powerful conductors of sound. The whole of the drum is lined by mucous membrane, which is continuous, behind with that of the mastoid cells, and in front, through the Eustachian tube, with that of the pharynx.

The *internal ear* or *labyrinth* is composed of two cases, an outer of bone, and an inner of membrane, fitting exactly into one another. Each of these cases has three parts:

(i) Vestibule.
(ii) Cochlea.
(iii) Semi-circular canals.

The two cases are separated from immediate contact by a layer of fluid (*perilymph*) while a further layer of fluid lies inside the membranous case (*endolymph*). The *auditory nerve*, together with the facial nerve, passes through the *internal auditory meatus* into the membranous labyrinth, and there gives off its terminal branches. Each of these ends in a pyriform cell, which is provided with cilia. The *vestibule* is in communication with the middle ear by the media of the membranes lying over the fenestræ ovalis and rotunda. Thus, when vibrations of air impinge upon the external ear, they are made to converge by the fossæ into the external meatus; passing along this they stimulate the membrana tympani and throw it

into vibration. These vibrations are conducted across the tympanum in part by the small bones, and in other part without their agency. Having crossed the tympanum, they throw the membranes over the fenestra ovalis and fenestra rotunda into vibration. These vibrations are communicated to the perilymph which passes them on to the walls of the membranous labyrinth and thence to the endolymph.

The movements of the endolymph thus produced stimulate the cilia of the auditory cells and thence impressions are conveyed by the filaments of the auditory nerve to its larger branches, and by these to the brain.

Therefore it follows that any imperfection of the auditory nerve itself, of its branches, or of any of the labyrinthine structures will prevent these vibrations being conveyed to the brain, and it is defect in one or other of these parts that produces nerve deafness.

But it equally follows that imperfections in the conducting apparatus (external or middle ear) will also prevent the endolymph being duly thrown into commotion. Thus, a foreign body or a plug of wax in the external meatus, blockage of the pharyngeal end of the Eustachian tube (by which air is prevented entering the drum, and so the drum-head falls inwards) inflammation of the tympanic mucous membrane, adhesions and ankylosis of the small bones, perforation of the drumhead, &c., will all

have their share in producing imperfection in a delicate organ in which every part must be in a state of perfect working order to ensure its work being properly done.

The *tongue*, or *organ* of *taste*, is situated in the floor of the mouth and is composed of muscle, fat, the hyoid bone, and the lingual vessels and nerves.

The tongue is connected with the symphysis of the lower jaw, also with the epiglottis; also with the *soft palate* (a fold of mucous membrane and muscles situated at the posterior part of the mouth); it lies in front of the *fauces*, which are mucous folds connecting the soft palate above with the tongue below. There is on each side an anterior and a posterior pillar, and between these lies a tonsil.

Each *tonsil* consists of a number of follicular glands or minute secreting crypts, liable to septic inflammation (*hospital sore throat*). Over the upper surface of the tongue are distributed *papillæ*, of three kinds:

(i) Circumvallate.
(ii) Fungiform.
(iii) Filiform.

These are small conical eminences, which become enlarged and inflamed during illness.

The tongue is considered to be typical of the state of the alimentary canal, and is therefore a helpful symptom in disease.

CHAPTER XII

INFLAMMATION

As a rule, inflammation accompanies all disease. Inflammation is produced by some irritant which acts like a poison.

The essence of inflammation is interference with the circulation; there is dilatation of all the blood-vessels, with first a quickening and then a slowing of the blood stream.

Blood consists of an albuminous fluid, containing solid elements (red and white corpuscles) salts, the elements of fibrin, water, and refuse. The red corpuscles are circular with a hollowed centre, in fact are bi-concave discs; they occupy the centre of the vessels and stick together on end in rouleaux; they contain hæmoglobin, which again contains iron and has an affinity for oxygen; red corpuscles do not change in shape.

White corpuscles exist in the blood and also in the tissues of the body; in the blood there is one white corpuscle to 300 or 400 red.

White corpuscles are larger than red and are constantly changing in shape, which is due to their amœboid movements—they have a tendency to travel along the sides of vessels and collect at any point of inflammation; they are sometimes called leucocytes.

Blood taken from the body coagulates, the coagulum consisting of fibrin and corpuscles; the upper layer white, as the white corpuscles are lighter than the red.

In inflammation, fibrin forms a network of fine threads, in which the blood corpuscles become entangled and so form a coagulum or clot.

In inflammation there is also effusion of coagulable fluid and abnormal multiplication of cells.

The visible symptoms of inflammation are—

(1) *Redness.* (3) *Heat.*
(2) *Swelling.* (4) *Pain.*

Redness is due to the increased flow of blood to the part.

Swelling is due partly to the dilatation of the blood-vessels, partly to the exudation of the fluid contents of the blood-vessels, and partly to the multiplication of cells.

Heat is due partly to the increased amount of blood in the part, partly to the extra amount of tissue destruction going on (functional activity).

Pain is due to the pressure on the nerves. Alteration of function almost always accompanies inflammation and is owing chiefly to the abnormal

multiplication of the cells of the part. If an inflamed part be examined under a microscope, the cells of the part will be seen to multiply and degenerate to embryonic form, and then to replace the solid tissue, which softens and liquefies and finally breaks down, the white corpuscles exude and migrate; they also multiply, degenerate, and help to destroy the solid material. In the blood-vessels, first the small arteries dilate, then the

Fig. 19.—Diagram of the minute changes in inflammation.

capillary vessels, then the veins. At first the blood circulates rapidly, next in the centre of the inflammation it oscillates and finally stagnates; all this gives rise to redness, swelling, heat, and pain.

Round the area of inflammation the arteries dilate and blood flows rapidly, and as the vessels become full of blood, the fluid material exudes into the extra vascular tissues; the white corpuscles exude through the walls and the red corpuscles stick together in a solid mass in the vessels. This exudation or plasma exudes through the walls of the blood-vessels into the extra-vascular tissues; it consists of water, albumen, salts, and fibrin in solution.

The chemical nature of the plasma depends on the tissue inflamed; in a serous membrane, such as the pleura, the exudation contains serum and lymph.

In inflammation of a mucous membrane there will not be so much exudation, and its chief chemical result will be mucine.

Suppuration, or the *formation of pus*, marks an intense degree of inflammation.

Pus is a thickish yellow fluid of alkaline reaction; it consists of albuminous fluid, holding in suspension a large number of granular cells or pus corpuscles, which closely resemble the white corpuscles of the blood and which render the fluid opaque.

The liquid is formed from plasma which has exuded from the blood, while the pus corpuscles are derived mainly from migrated leucocytes.

Suppuration also implies destruction and degeneration of tissue.

Causes of inflammation.

(1) *Traumatic* or *mechanical injury*, as in a compound fracture.

(2) *Physical injury*, as cold, causing internal inflammation, as in pleurisy.

(3) *Micro-organisms*, which if introduced into the body produce certain chemical poisons which irritate the tissues and set up inflammation.

(4) *Inorganic poisons*, which if introduced into the body in excess, cause inflammation and especially affect the liver.

Constitutional Symptoms of Inflammation.

(1) *Rise of temperature.*

(2) *Headache.*

(3) *Thirst.*

(4) *Diminished secretions of alimentary canal.*

(5) *Urine highly coloured and laden with effete matter.*

If it were possible to examine the blood, that also would be found to be laden with effete matter which tends to affect the functions of the liver and kidneys.

Inflammation may be acute, sub-acute, or chronic; its degree depends on the amount of poison in the system: if there is a large quantity of poison the inflammation will be acute, if small less acute.

Chronic inflammation may follow acute inflammation, or may arise quite independently of it.

Ulceration always occurs on the surface and is

destruction of the tissues from inflammation, particle by particle.

Gangrene, *Mortification*, or death of the part, is generally owing to interference with the blood supply to the part which leads to its death. The skin becomes black and has blebs upon it (bullæ).

Repair is brought about by a process similar to inflammation.

In this process ulceration and suppuration cease, while the embryonic corpuscles, entangled in the coagulated fibrin, throw out delicate processes which unite with one another to form a network, in the meshes of which the fibrin is then contained; new vessels and new nerves start from the normal vessels and nerves and permeate the newly formed tissue, or by degrees some of the leucocytes amalgamate and form what are called granulations which, in process of time, unite with other granulations.

Complex tissue never grows again; granulations are changed into hard connective tissue and the scar (cicatrix) is covered by an elongation of skin; the cicatricial substance has no power of forming true epidermis.

Repair is generally described as healing, (1) by immediate union; (2) by primary intention; (3) by secondary intention, or by granulation; (4) by tertiary intention or union of two granulating surfaces.

Healing by *first intention* is shown in a clean cut, where the sides being brought closely together

are united by means of coagulable fluid. *Granulations* form in the lowest part of a wound and also on the edges of a wound, thus a wound heals from the centre and is closed in by two granulating surfaces, which gradually grow together.

The internal method of repair is similar to the external method, the repairing tissue being as a rule similar to the normal tissue of the organ; for instance, a fractured bone is united by callus and that in time ossifies.

A fractured *patella* differs from other bones in being united by a layer of fibrous tissue.

Repair of arteries is brought about by the formation of a *thrombus* or *clot.*

The thrombus may be absorbed from the injured vessels; then the leucocytes, aided by sprouts from the vessels, form a fibrous tissue which becomes adherent to the walls of the vessel and so strengthens them.

The terminations of inflammation are:

(1) Resolution.

(2) New formation.

(3) Suppuration.

(By abscess we understand the formation of pus in a solid part; pus can never be absorbed and must be let out; it therefore should be treated surgically.)

(4) Ulceration—destruction of tissue particle by particle.

(5) Gangrene—(mortification, death of a part, slough) a destruction of the tissues *en masse.*

CHAPTER XIII

FOOD AND ITS USES

Food is that which supplies us with energy, by means of which we are able to work; it repairs the tissues by supplying Protoplasm.

The ultimate structure of all the tissues of the body consists of cells derived from protoplasm.

And protoplasm is formed by a chemical combination of:

(1) Carbon. (4) Nitrogen.
(2) Hydrogen. (5) Phosphorus.
(3) Oxygen. (6) Sulphur.

Foods may be divided into two classes:

(1) Organic. (2) Inorganic.

Organic foods are further divided into:

(1) Nitrogenous. (2) Non-nitrogenous.

Nitrogenous foods consist of Carbon, Hydrogen, Oxygen, Nitrogen, and comprise all vegetables and the flesh of birds, fish, and mammals.

Non-nitrogenous foods consist of three elements:

(1) Carbon.
(2) Hydrogen.
(3) Oxygen.

Under this head come sugar, starches, and fats.

Another plan of division is:

(1) Carbohydrates (sugars and starches).
(2) Fats.
(3) Proteids (nitrogenous compounds).
(4) Mineral salts.

A proper diet should consist of one part nitrogenous to three and a half or four and a half non-nitrogenous material.

Or, as it may be expressed, the ratio of carbon and nitrogen in a perfect diet should be thirteen parts of carbon to one part of nitrogen.

In bread, for example, we have twenty parts of carbon to one part of nitrogen; therefore bread is rich in carbohydrates, but deficient in proteid.

A somewhat fanciful classification of food is:

(1) Proteids (flesh-formers).
(2) Carbohydrates and fats (body-warmers).
(3) Salts, principally phosphates (bone-formers).

Now, food to be conveyed to the tissues in a suitable form for absorption must pass through the process of digestion.

By digestion (Lat., *digerere*, to carry in various directions) we understand the various chemical processes by means of which the nourishing part of our food is separated from that which is not nourishing, and the mode by which the nourishment thus gained is carried to the tissues.

It is the function, therefore, of the digestive

organs to act upon our food, and by means of certain chemical agencies, in the saliva, in the

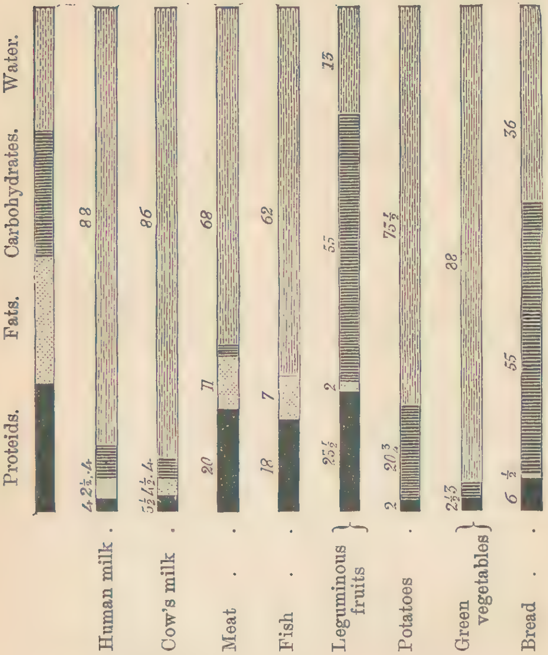

Fig. 20.—Diagram showing the proportion of the principle food-stuffs in a few typical comestibles. The numbers indicate percentages. Salts and indigestible materials omitted.

gastric juice, and in the pancreatic and hepatic juices, either to dissolve the food, or to break it up

into the smallest possible globules suitable for assimilation.

A carbohydrate consists of the element carbon (C) united with water (H_2O).

Starch is a carbohydrate. The chemical formula for starch is $C_6H_{10}O_5$ or $C_65(H_2O)$.

Starch is a white, amorphous powder, not soluble in cold water; when pure, tasteless; if boiled, forming a mucilage, or jelly; it is also very easily dissolved.

In the mouth starchy foods are dissolved and converted into sugar by a substance in the saliva, called ptyalin. When starch is heated, a chemical change takes place, and the starch is converted into dextrine (a gummy substance formed by the action of heat and acids upon starch.)

This change takes place in flour.

Bread is made by mixing flour and water into a paste, called dough, which is very tenacious and close. Flour contains, besides starch, a proteid (gluten), which gives the toughness to the dough.

For the separation and breaking-up of this gluten in the making of bread, yeast is used.

Yeast is a living plant, which will grow in a solution of sugar.

Yeast causes fermentation, a chemical operation by means of which starch is converted into sugar. The dough is kept for a time in a warm place, and by the yeast, starch is converted into dextrine, and

breaks up again into carbonic acid gas (CO_2) and water (H_2O).

It is really the action of the CO_2 which separates the gluten and aërates the bread.

For this purpose also baking powders, containing carbonate or bicarbonate of soda and tartaric acid, are used, as by the action of the acids on the car bonates CO_2 is formed, and the gluten is thus separated and the bread aërated.

Chemical Constituents of Bread.

	Per cent.
Carbohydrates . . .	49·4
Fats	1·3
Proteid	8·0
Mineral salt	1·3
Water	40·0

All proteids (often also termed albuminoids) contain carbon, hydrogen, oxygen, and nearly always 15 per cent. of nitrogen. There are both animal and vegetable proteids. The amount of nitrogen in most plants is 15 per cent. Animal proteid is more easily digested than vegetable by the ferments of the various digestive juices. A principal proteid is albumen, found in its simplest form in white of egg; this may be considered an albuminoid, or type of soluble proteid. Some idea of the amount of proteid in different foods may be formed from the following scale:

Proteid in Food.

	Per cent.
Meat	20
Fish	18
Eggs	14
Bread	8
Milk	4
Potatoes	$1\frac{1}{2}$

The only food prepared for us naturally in exact chemical proportions to sustain life is milk.

Chemical Constituents of Milk.

	Per cent.
Carbohydrates	4·8
Fats	3·7
Proteid	4·0
Salts	·7
Water	86·8

Milk may be defined as an emulsion of fat in a watery solution of soluble proteids and salts. If milk is allowed to stand, cream rises to the top, which is a partial separation of the fat.

Good milk should give 10 to 12 per cent. cream.

The total amount of solids in milk should be 13 per cent.; with fats removed, 9·5 per cent.

When milk is boiled a scum is given off, a soluble proteid—viz., albumen.

The chief proteid in milk is called casein; and

skim-milk and buttermilk, although deprived of fat, are still very nourishing.

Inorganic foods comprise mainly water, salts, and phosphates.

Water is a most useful ingredient in our systems; it serves to dilute the more solid portions of our food, to carry them to the various tissues of the body, and to wash away waste material.

It appears, then, that the use of food to the body is to repair the waste of all tissues and to produce heat, muscular power, brain power, and power to form secretions and excretions. The origin of our bodily powers is now said to be owing to the transformation of force brought about by the influence of the sun's rays. The sun's rays are a means of chemical force. We give off from the body carbonic acid gas; the green leaves of plants, under the influence of the sun's rays, have the power of decomposing CO_2, by taking up the carbon and setting free the oxygen.

One fifth of the atmosphere consists of oxygen, which we draw in as we breathe, and without which we cannot live. Four-fifths of the atmosphere consist of nitrogen, which we require but cannot take from the air; but plants, under the influence of the sun's rays, combine carbon and nitrogen in their structure, taking the carbon from the air and the nitrogen from the soil. Therefore when we eat plants, digestion decomposes these elements, and the force which

bound them together imparts to us heat and vital power.

Thus, also, animals feed on plants, digest them, and store up chemical force, which again is imparted to us when we feed on them.

It is proved, also, that the different elements of which our food is composed are given off in various forms from the body.

Oxygen, drawn into the lungs, combines with the carbon in the blood derived from food, and is given off by the breath and the skin, in the form of carbonic acid gas (CO_2).

Hydrogen combined with oxygen is given off as water (H_2O) by the breath, in perspiration, and in the urine.

Nitrogen is eliminated from the system in urea, salts, and phosphates.

Food taken into the body may be considered as fuel, giving rise to the body's heat by the setting free of chemical force.

The heat of the body is called its temperature; and in health a certain amount of heat is used up in tissue-construction. In disease, however, tissue-construction is at a standstill; consequently the heat naturally used up in tissue construction is set free and the temperature of the body rises. This fact will also explain the wasting which takes place in prolonged fevers.

CHAPTER XIV

VENTILATION

By ventilation we understand the removal of impure air, so that an access of pure air from the outside atmosphere may take its place. Air is made up of gases and is invisible, without colour, taste, or smell. The air we inhale is composed of oxygen 21 per cent., or about one-fifth of the whole, and nitrogen 79 per cent., or about four-fifths, with a trace of carbonic acid gas and a variable proportion of watery vapour; whilst the air we exhale contains about 5 per cent. *less* oxygen and 5 per cent. *more* carbonic acid gas, with an increased proportion of watery vapour, the nitrogen remaining about the same. Oxygen is the life-giving principle of the air, whilst nitrogen extinguishes life, but serves to dilute oxygen as water does wine.

We cannot live without oxygen; if a person were to shut himself in a room without any means of ventilation, the air he breathed would gradually be deprived of oxygen and its place taken by CO_2,

which would be inhaled and by degrees saturate the blood, and would in time cause death from asphyxia (cessation of pulse caused by suffocation), more due to the deprivation of oxygen than to the effects of CO_2, which in small quantities is only slightly poisonous and produces no immediate effect on the animal system if the supply of oxygen is increased in proportion. It is very questionable if it is the CO_2 (*per se*) which is poisonous. In expired air organic matter is in exact and perpetual ratio with the CO_2, and it is the organic matter which mainly does the damage if not exhaled.

In cases of drowning, choking, &c., no oxygen can enter the blood, whilst CO_2 is rapidly accumulating and rendering the blood venous; death occurs in a few minutes partly from CO_2 poisoning, but chiefly from starvation for want of oxygen, and to excess of organic matter.

Proper ventilation for a sick-room is best described as clean air displacing foul air constantly and steadily, without chilling the patient.

The air outside our room is colder as a rule than that inside, and what we wish to do is to let out the used-up air, at the same time introducing external air and warming it as it enters the room.

It is proved by experience that a very satisfactory manner of ventilating a sick-room is to keep a fire burning, and to have the windows open a few inches at the top. By this means the warm

foul air, which being lighter has a tendency to ascend, will pass up the chimney, and its place will be supplied by external air coming in at the top by the window; and as cold air being heavier has a tendency to descend, it will come down into the room and be gradually warmed as it mixes with the internal air in its descent.

Ventilation, to be thorough, must be systematic and not supplied in jerks. It is frequent changes of temperature that do harm. An inrush of cold air makes a draught and causes discomfort and frequently gives cold, particularly to those suffering from illness, whose vital power is lowered for the time. An excellent method of ventilation is to have perforated openings in the upper part of the wall, connected with a shaft leading to the outside, by which warm air may escape, and to have a piece of wood the exact width of the window frame inserted underneath the lower sash which would close down upon it. In this way air must enter by the space between the sashes, which of necessity are open when the lower sash is raised.

A patient cannot then see that the window is open and will probably not complain, also very little draught is felt in this way.

Careful ventilation is an important point of skilful nursing, and requires judgment and common sense. In order, therefore, to ventilate thoroughly we must have an inlet for fresh air, and an outlet for foul air.

Those who think to ventilate by one opening deceive themselves; for the warm, foul air going out interferes with the entrance of the fresh air. In the ventilation of rooms, wards, &c., it is better that the outlet for foul air should be near the ceiling, because hot air is warm and heat expands, and therefore makes things light, and they ascend.

The inlet for fresh air should be lower down, and arranged to avoid draughts, because fresh air is cold, and being heavy has a tendency to descend. Door and window of a sick-room should never be open at the same time; that always causes a draught. Nurses should remember that "windows are made to open, and doors are made to shut."

Night air is often the freshest in the twenty-four hours, particularly in London and big towns; it is therefore a good plan to keep the windows open at night a couple of inches at the top.

There should always be a fire in a sick room, as in this manner air is warmed and also carried up the chimney.

Combustion also is supported by oxygen; therefore a fire burning brightly proves the presence of plenty of oxygen.

The temperature of a room is easily told by the thermometer, which, though it does not show the freshness of the air, is a very useful guide.

Temperature of an ordinary dwelling-room should be about 57°.

Temperature of a surgical ward or sick-room should be about 58°.

Temperature of a medical ward or sick-room should be about 63°.

Temperature of theatre for ordinary operations should be about 65°.

Temperature of theatre for abdominal operations should be about 70°.

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